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Report of THE TENTH DRY BEAN RESEARCH CONFERENCE

August 12-14, 1970 Davis, California

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THE TENTH DRY BEAN RESEARCH CONFERENCE was held August 12-14, 1970, at the University of California, Davis. It was attended by bean growers, shippers, and processors from various growing areas, as well as by research and extension workers from State and Federal agencies. The program was composed of papers reporting results of current research on the production, marketing, and utilization of dry beans.

On August 13 the Agronomy Department of the University conducted a tour of the experimental bean plots. The conference concluded on August 14 with a talk by Gus Arriolo, creator of the cartoon character Gordo. He told the story of Gordo's "frijoles con queso," one of the most unusual and successful marketing techniques for dry beans.

Sponsors of the conference were the National Dry Bean Council, the California Dry Bean Industry, the University of California (Davis), and the U.S. Department of Agriculture. E. J. Fash, President of the National Dry Bean Council, was General Chairman. Paul F. Knowles, Chairman of the Department of Agronomy and Range Science, welcomed participants to the University campus. Carl Tucker, University of California, and Bernard Feinberg, Western Regional Research Laboratory, Agricultural Research Service, USDA, Albany, Calif., were program cochairmen. The advice and assistance of Joseph R. Wagner of the Western Regional Research Laboratory and William McCormack and Neele Johnston of the Trinidad Bean and Elevator Company are gratefully acknowledged.

This report was prepared in the Western Regional Research Laboratory, Albany, Calif. 94710, headquarters of the Western Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture. *Statements made by speakers at this conference are their own and they may not reflect the position of the U.S. Department of Agriculture. Those interested in reproduction must obtain permission from the speaker or his organization.*

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PATHOGENIC VARIATION IN *PSEUDOMONAS PHASEOLICOLA*: AN ANALYSIS OF RACE 1 AND RACE 2 STRAINS[1/]

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A study of the nutritional and pathogenic variability of *Pseudomonas phaseolicola* was begun several years ago as part of an investigation into the halo blight group of pseudomonads. Isolates were collected from around the world and tested against a number of bean varieties, including representatives of the common bean, soybean, and lima bean. This paper presents an analysis of the results that were obtained (2) in testing *P. phaseolicola* strains against *Phaseolus vulgaris* varieties with particular reference to race 1 and race 2 as designated by Patel and Walker (1).

Thirty-three strains of *Pseudomonas phaseolicola* were tested against 22 varieties of *Phaseolus vulgaris*. (See (2) for source of *P. phaseolicola* strains.) Plants were grown in a greenhouse at ca. 21 ± 4° C. Inoculations were made 7 to 10 days after planting by dusting the leaves with corundum and then rubbing them lightly with a cotton swab dipped in a bacterial suspension of about 10^9 cells/ml. Symptoms were observed 2 to 5 days after inoculation. These were recorded as: 0 (no reaction to very slight browning); T (tolerant reaction, characterized by the appearance of lesions with a greasy appearance or by small watersoaked spots that became dry and necrotic 12 hours or less after their appearance); 1 (ca. 1 lesion/cm.^{2}); 2 (ca. 5-15 lesions/cm.^{2}); and 3 (ca. 25 lesions/cm.^{2}). In many cases lesions were larger in reactions with a 3 rating.

The variety Red Mexican UI-3 was the differential designated by Patel and Walker (1) for distinguishing race 1 and race 2 strains of *P. phaseolicola*; it is resistant to all race 1 isolates and susceptible to all race 2 isolates.

1/ This investigation was supported in part by Regional Research Funds 2444 (W-96), USDA grant (12-14-100-9199-34), and a Public Health Service research career development award to D. C. Hildebrand (K3-AI-34,942) from the National Institutes of Allergy and Infectious Diseases.

Therefore, for the race 1 and race 2 analyses, 33 strains of P. phaseolicola were separated according to their reaction on this variety. Twelve strains produced a 0 reaction on Red Mexican and thus were designated race 1. Ten strains produced a 1 to 3 reaction and thus were designated race 2. The 11 remaining strains produced a tolerant reaction, which according to the Patel and Walker system, characterized them as race 1. These were designated race 1T for convenience in distinguishing them from other race 1 strains which produced no reaction.

The data were analyzed in three ways. The first analysis consisted of determining the total number of each reaction-type strain of races 1, 1T, and 2 produced on the bean varieties (excluding Red Mexican to eliminate bias). This analysis is presented in table 1. In general, this

TABLE 1.--Totals of various reaction types produced by race 1, race 1T, and race 2 strains of Pseudomonas phaseolicola on 21 varieties of beans

Reactions	Race 1[1,2/]		Race 1T[1,2/]		Race 2[1,2/]	
	Number	Percent	Number	Percent	Number	Percent
0	16	6.5	4	1.8	2	0.9
T	44	17.8	38	16.8	10	4.7
1	102	41.1	73	32.4	56	26.5
2	68	27.3	86	38.0	88	41.7
3	18	7.2	25	11.0	55	26.2
Totals	248	100.0	226	100.0	211	100.0

1/ Twelve strains of race 1, 11 of race 1T, and 10 of race 2 were tested. 2/ Percentage of total reactions.

analysis suggested that the separation of the strains into races 1, 1T, and 2, on the basis of their reaction on Red Mexican, was basically a reflection of their overall degree of virulence on other bean varieties. Thus, for example, race 1 strains produced 16 type 0 reactions out of a total of 248, whereas, race 2 strains produced only 2 type 0 reactions out of 211. Further, race 1 strains produced 18 type 3 reactions, whereas race 2 strains produced 55. In both cases the number of reactions produced by race 1T strains were intermediate between the other two groups.

The second analysis was made to determine the relative virulence of each isolate. A numerical value was assigned to each reaction: 0 = 0; T = 1; 1 = 2; 2 = 3; and 3 = 4; and an average was obtained for the strain reaction

on all beans (table 2). Data further indicated that the reactions on Red Mexican were distinguishing populations with differences in the degree of virulence. The average virulence ratings were 2.1 for race 1, 2.4 for race 1T, and 2.9 for race 2. The range of the virulence ratings was 1.2 to 2.8 for race 1 strains, 1.7 to 3.1 for race 1T, and 2.2 to 3.4 for race 2.

Our final analysis consisted of rating the susceptibility of each bean to the strains of each race. The numerical values assigned to the reaction ratings were used in this analysis also. None of the 21 bean varieties exhibited equal or greater susceptibility to race 1 isolates than to race 2 isolates (table 3). Furthermore, there was only one bean variety which was rated more susceptible to race 1T than to race 2, and this was by an insignificant 0.1. Three of the 21 bean varieties had a lower susceptibility rating to race 1T than to race 1 strains.

It appears from these analyses that the separation of P. phaseolicola strains into race 1 and race 2 on the basis of their reaction of Red Mexican in most cases is a separation of strains with different degrees of virulence. Thus, strains which produce 0 reactions on Red Mexican are generally weaker in virulence on all other beans than those which produce a T reaction. Likewise, those strains which produce a T reaction were less virulent in general than those which produced a 1 or 2 reaction on Red Mexican.

Virulence varies greatly among P. phaseolicola strains, as was noted by Patel and Walker (1). Red Mexican is a highly resistant variety and even highly virulent strains of P. phaseolicola produce at best only moderate symptoms. It is not surprising, therefore, that weakly virulent isolates will not attack this variety. We have made analyses (not presented) using other resistant beans such as Pinto UI-114 as differentials and have obtained similar virulence distribution patterns. The individual strain composition of the virulence groups obtained, however, differs from the composition of the groups (races 1, 1T, and 2) obtained with Red Mexican. This is because there are differences in the relative degree of virulence among strains of the pathogen and, also, in the absolute virulence of individual strains toward a given bean variety. Thus strains HB 36 and HB 39 produce a 3 and a T reaction, respectively, on Small White 59, although both would be considered race 2 strains and both have a high virulence rating (3.3 and 3.0, respectively). This diversity extends

TABLE 2.--The virulence ratings of Pseudomonas phaseolicola strains when tested against 21 varieties of beans

Race 1		Race 1T		Race 2	
Strain designation	Virulence rating[1/]	Strain designation	Virulence rating[1/]	Strain designation	Virulence rating[1/]
2	2.5	18	2.5	1B	2.7
8	2.3	26	3.1	13	2.5
9	1.8	28	1.7	14	2.2
11	1.8	29	2.5	16	3.0
20	1.5	30	2.4	27	3.1
23	2.8	31	2.0	36	3.3
24	2.8	33	2.5	37	3.4
25	1.2	38	3.0	39	3.0
32	2.0	40	2.8	41	2.4
34	1.8	45	1.9	42	3.0
35	2.0	46	1.8	--	--
43	2.8	--	--	--	--
Average	2.1	--	2.4	--	2.9

[1/] Average virulence for each strain based on its reaction on 21 bean varieties. The scale used was: 0 reaction = 0; tolerant reaction = 1; ca. 1 watersoaked lesion/cm.^{2} = 2; ca. 12 watersoaked lesions/cm.^{2} = 3; and ca. 25 watersoaked lesions/cm.^{2} = 4.

TABLE 3.--The susceptibility of bean varieties against strains of race 1, race 1T, and race 2 of Pseudomonas phaseolicola

Bean variety	Race 1[1/]	Race 1T[1/]	Race 2[1/]
Blue Lake White Seeded	1.8	1.8	2.7
Bountiful Green Pod	2.3	2.8	3.0
Bush Blue Lake	2.0	2.4	2.6
Early Wax	2.9	2.8	3.5
Great Northern US-1140	1.6	1.9	2.4
Improved Super Green	2.5	2.8	3.3
Improved Top Notch	1.7	2.3	2.9
Kentucky Wonder White Seeded	2.0	2.6	2.5
Pencil Pod Wax	2.3	2.5	2.6
Pinto UI-111	1.8	2.3	2.5
Pinto UI-114	1.2	1.8	2.1
Red Kidney "Red Kote"	2.0	2.0	2.2
Resistant Cherokee	2.5	2.6	3.2
Romano	2.3	2.4	2.9
Small White 59	1.3	1.8	2.5
Sutter Pink	1.6	2.0	2.7
Tender Crop, Burpee	2.9	2.7	3.7
Tender Crop, White Seeded	3.1	2.6	3.3
Top Crop	2.3	2.6	3.3
Wren's Egg, Burpee	2.2	2.4	2.8

[1/] Represents the numerical average of the disease reactions of all P. phaseolicola-type strains on each bean variety. The scale used was: 0 reaction = 0; tolerant reaction = 1; ca. 1 watersoaked lesion/cm.^{2} = 2; ca. 12 watersoaked lesions/cm.^{2} = 3; and ca. 25 watersoaked lesions/cm.^{2} = 4. Red Mexican UI-3 reactions for race 1, 1T, and 2 were 0, 1, and 2.1, respectively.

throughout all strains of P. phaseolicola tested, whether designated race 1 or race 2. Because of this virtually every strain could be designated as a different race if so desired.

Whether P. phaseolicola strains should be divided into races seems to be debatable at present. The main benefits derived from race designation is that it emphasizes that considerable variation exists among P. phaseolicola strains in virulence and pathogenicity and emphasizes the need to use several strains of the pathogen when breeding and testing beans for resistance.

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BREEDING GREAT NORTHERN DRY BEANS TOLERANT TO THE COMMON BLIGHT (*XANTHOMONAS PHASEOLI*) AND WILT BACTERIA (*CORYNEBACTERIUM FLACCUMFACIENS*)[1/]

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Nebraska has a successful dry bean industry and for many years about 80,000 acres of beans have been grown (1). The bulk of this acreage is devoted to Great Northern (G.N.) and the remainder to pinto beans. In order to obtain a large measure of control of the bacterial diseases, the seed for these crops has been produced in Idaho. However, in years when conditions are favorable for spread and multiplication of bacteria, crop losses have been sustained from the common blight and bacterial wilt diseases. There are no satisfactory chemical control measures for these diseases and no bacterial disease tolerant commercial varieties are available. The introduction of tolerant varieties would reduce the losses due to these diseases and would permit the establishment of a new bean seed industry in Nebraska.

The research reported in this paper concerns the development of Great Northern dry beans (*Phaseolus vulgaris* L.) tolerant to the bacteria *Xanthomonas phaseoli* [(E. F. Sm.) Dows.] and *Corynebacterium flaccumfaciens* [(Hedges) Dows.]. This entailed the development of effective and reliable inoculation procedures, identification of germ plasm tolerant to the bacteria, determination of the genetic control of the disease reactions, selection of tolerant plants in segregating populations, and evaluation of the performance of advanced lines in comparison with standard G.N. varieties in field tests. The genetic control of a photoperiod-temperature response for time of flowering in beans is reported. The usefulness of this information in developing early maturing beans is discussed.

The bacterial suspensions of *Xanthomonas phaseoli* were prepared by washing off a culture of the bacteria growing on a petri plate and suspending the bacteria in

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[1/] Published with the approval of the Director as Paper No. 2833, Journal Series, Nebraska Agricultural Experiment Station.

one-half liter of water. The plants in the field were inoculated by means of a power sprayer at about 150 p.s.i. (2). It is possible to obtain water soaking of a few leaves of each plant by this means of inoculation. The plants were inoculated about 8 to 10 a.m. when most of the stomata were wide open. The plants were generally starting to bloom at the time of spraying.

The suspension of Corynebacterium flaccumfaciens was prepared by washing off a culture of the bacteria growing on a petri plate in 15 ml. of water. One cotyledon, while still in a plump condition, was pinched off flush with the stem. A dissecting needle, which had been previously dipped in the bacterial suspension, was inserted into the stem at the point of the cotyledon attachment. This has proved to be a very reliable inoculation procedure.

High temperatures that prevail in summer in western Nebraska are favorable for the multiplication of both species of bacteria in plants. Severe disease symptoms develop on susceptible plants and thus facilitate the selection of tolerant plants in segregating populations.

Most of the plant introduction bean collection and numerous varieties were inoculated with the bacteria causing common blight and bacterial wilt diseases. A late rogue plant found in the G.N. Nebraska #1 dry bean variety and designated as selection #27 was found to have high tolerance to the bacteria causing common blight. The late-maturing G.N. Nebr. #1 sel. 27 was crossed to the early maturing common blight susceptible G.N. 1140 to determine the inheritance of the disease reaction and to combine in a G.N. dry bean tolerance to common blight and early maturity. The reaction to the bacterium causing common blight was quantitatively inherited and heritability was high.

P.I. 165078 and P.I. 136725 showed high tolerance to the wilt organisms under greenhouse conditions (temperature about 21° C.) in winter. However, under high temperature conditions in summer in the field, P.I. 136725 became susceptible in the early stages of maturity. P.I. 165078 remained tolerant at all stages of growth under these conditions and was considered a desirable parental material for use in breeding under Nebraska conditions. The two tolerant parents were crossed to the various dry bean types and the disease reaction was observed to be largely under qualitative genetic control, with tolerance being recessive. The purpose of the cross P.I. 165078 X G.N. varieties was to combine large seed size, bright white seed coat, and

tolerance to wilt bacteria in a G.N.-type bean.

Both a pedigree and backcross breeding systems are being used to develop beans tolerant to these bacteria. A backcross program is also being continued to develop earliness and tolerance to both common blight and bacterial wilt in beans of G.N. type. It has been possible to transfer high tolerance to bacterial wilt and earliness in this program. In the original cross between the two late-maturing lines, G.N. Nebr. #1 sel. 27 and P.I. 165078, some early maturing bacterial wilt tolerant segregates were found and these were used in backcrossing to Nebr. #1 sel. 27. This latter parent was used as the recurrent parent. The reaction to the common blight bacteria is quantitatively controlled so that following this procedure it should be possible to combine high tolerance to common blight, along with bacterial wilt and earliness.

A large number of advanced common blight breeding lines were compared with standard G.N. varieties in inoculated and noninoculated trials from 1966 through 1969. Based on these trials, the tolerant breeding line Nebr. 65-4-72 was selected for release and the variety name Tara assigned. The data indicate that both commercial and seed production of Tara are possible in Nebraska because of the variety's high common blight tolerance. Certified seed of Tara is being grown in Nebraska in 1970. Another breeding line, Nebr. 67-90 was recently selected for release and the variety name Jules assigned. Jules possesses higher common blight tolerance and higher yield than Tara but is about 3 to 5 days later in maturity, which is a disadvantage in western Nebraska.

Advanced Great Northern bacterial wilt-tolerant lines have been developed and have been compared with standard varieties at several locations from 1968 through 1969. These lines are comparable in yield and maturity with the standard varieties. One line which has a seed size comparable with that of G.N. UI 59 and another line which has a seed size much larger than that of G.N. UI 59 may be released in 1970. There is a demand in the European markets for a large, bright, white dry bean. Presently, supplies of this type come from the Balkans. This large type may provide a new market outlet for Nebraska beans.

A common blight tolerant G.N. Nebr. sel. 27 and bacterial wilt-tolerant P.I. 165078 parents used in the crosses reported in these studies are late flowering and

do not mature early enough in many seasons to produce ripe pods under the short growing season of western Nebraska. It is necessary to combine the genes controlling the disease tolerant reaction of these parents with the suitable earliness of G.N. 1140 or G.N. UI 59.

An experiment was conducted in growth chambers to study the effect of photoperiod and temperature regimes on time of flowering of G.N. 1140 and P.I. 165078. It was observed that P.I. 165078 flowered at a later date than G.N. 1140 when grown under long days, 14 hours, 29.4° C. and 26.7° C. day and night, respectively, but there was no significant difference in date of flowering of the varieties under the same photoperiod, 26.7° C. and 21.1° C. day and night, respectively. The increase in temperature under a 14-hour day produced a differential response in date of flowering of the varieties. When the photoperiod was increased from 14 to 16 hours, under temperatures 29.4° C. and 26.7° C. day and night, respectively, a significant delay in the date of flowering of both G.N. 1140 and P.I. 165078 was observed. The data indicated that under the higher temperature regime used here, delayed flowering of P.I. 165078 occurred under 14-hour photoperiod. A longer photoperiod of 16 hours was necessary to cause a delay in flowering of G.N. 1140.

These are important types of genotype-environment interactions which a plant breeder has to consider in developing varieties of suitable maturity adapted to different climatic regions.

Parental F_1, F_2, and BC_1 and BC_2 populations of the cross G.N. 1140 X P.I. 165078 were grown in the field. It was observed that time of flowering was controlled primarily by a single major gene with late flowering being recessive.

In breeding G.N. dry beans, it would be desirable to develop lines possessing the gene for the early flowering of G.N. 1140. When compared with G.N. 1140, G.N. Nebr. #1 sel. 27 and P.I. 165078 are very sensitive to long days and high temperature and are late flowering under these conditions. A backcross program could readily be used to transfer the gene controlling the early time of flowering of G.N. 1140 into extremely sensitive short-day types.

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INTERRELATIONSHIPS BETWEEN SEED MOISTURE, IMBIBITION TEMPERATURE, AND OXYGEN STRESS DURING BEAN GERMINATION

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The problem of plant establishment, particularly of planting "to stand" for optimum plant populations, is one key to decreasing costs in modern agriculture. To obtain the full benefit from planting to stand, it is essential that we understand, and have the ability to control, seedling vigor, particularly uniformity of seedling vigor.

Several years ago, we started to investigate the meaning of seed and seedling vigor in beans as a model system for the study of establishment problems in other vegetable crops. The original work was done with lima beans. It was extended to garden beans, and, more recently, we have begun to look at dry beans. Although I have only preliminary data available on dry beans, I would like to review for you the current status of our research on stand establishment in other types of beans. In doing this, I would like to indicate some of the questions, as yet unanswered, which will be of importance to plant breeders, seedsmen, and bean producers who wish to apply our information to their own practical problems.

Our work on beans started with the suggestion by Bob Wester, the USDA lima bean breeder, that seed color in baby lima beans offered a good objective separation of high and low vigor seeds. These seeds are normally green at maturity. However, if they remain too long in the windrow, the chlorophyll is destroyed and the seeds become "bleached." The bleached seeds are recognized in the trade as being of low vigor. Commercial seed lots are frequently color-sorted and the green seeds sold at a premium price. Our problem was to convert the bean growers' subjective recognition of vigor levels into an objective measurement of vigor which we could utilize experimentally.

In germination, all growth occurs in the small embryonic axis of the seed. The bulky cotyledons serve primarily as a source of reserve nutrients. Before joining the USDA, I had been studying the metabolism of embryonic axes. Therefore, in comparing bleached and green seeds,

it seemed reasonable to focus our attention on the comparative responses of the embryonic axes from the two types of seeds.

We found (5) that axes, excised from dry seeds, could be placed in water and would grow for about 24 hours (fig. 1). Imbibition and growth followed a well-defined pattern which could be measured by weighing the axes at intervals. Figure 2 shows that this pattern includes imbibition of water for about 2 hours, a lag period for approximately 4 hours, and finally a period of linear growth. We used the rate of growth during this linear growth period as a measure of axis quality or experimental treatment.

One of the first things we discovered was that the rate of growth during the linear growth period is determined by the temperature during the first few minutes of imbibition. This is a delayed temperature effect, in contrast to the direct temperature effects with which we are all more familiar. The temperature curves shown in figure 2 are for temperature exposure during the first 30 minutes of imbibition. Subsequent growth occurred at the same temperature (25° C.) in all treatments. The temperature-sensitive period is short, approximately 10 minutes (fig. 3). Chilling injury

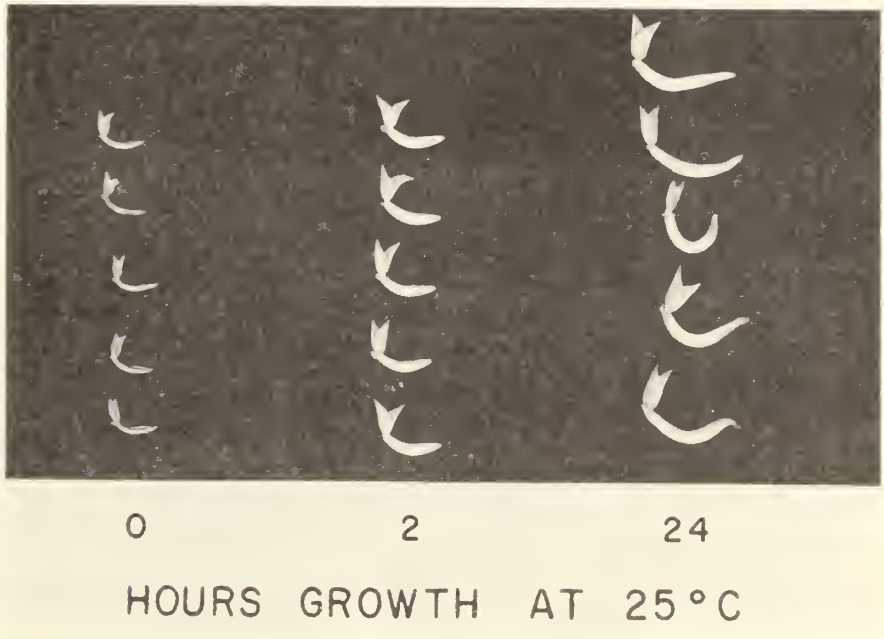

Figure 1.--Increase in size of lima bean axes placed in water. During the first 2 hours the increase is due to physical imbibition of water. From 2 to 24 hours the increase is growth; some seedlings show tropic response.

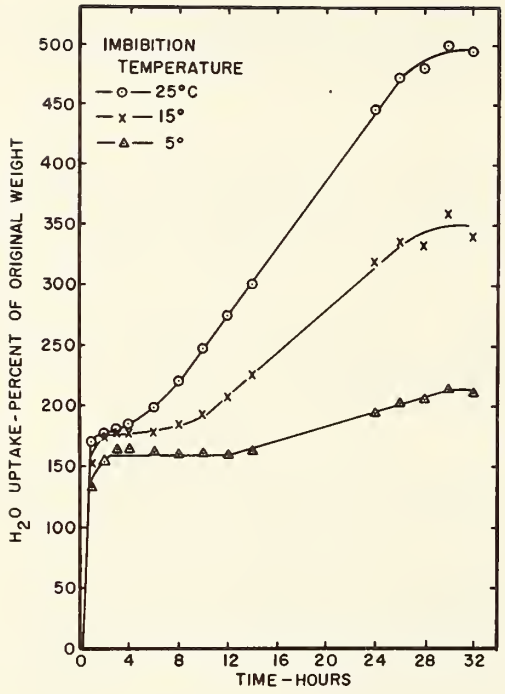

Figure 2.--Time course of imbibition and growth of excised lima bean axes. Figure from (5).

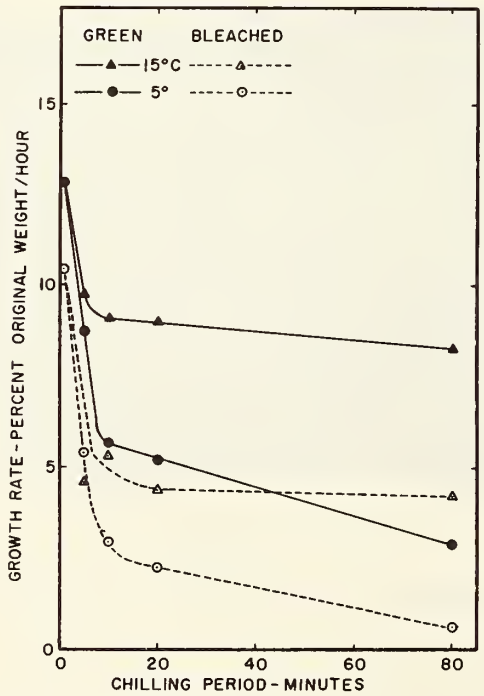

Figure 3.--Temperature-sensitive period of excised lima bean axes. Figure from (5).

can be eliminated by imbibing at 25°C. before exposure to low temperature (fig. 4).

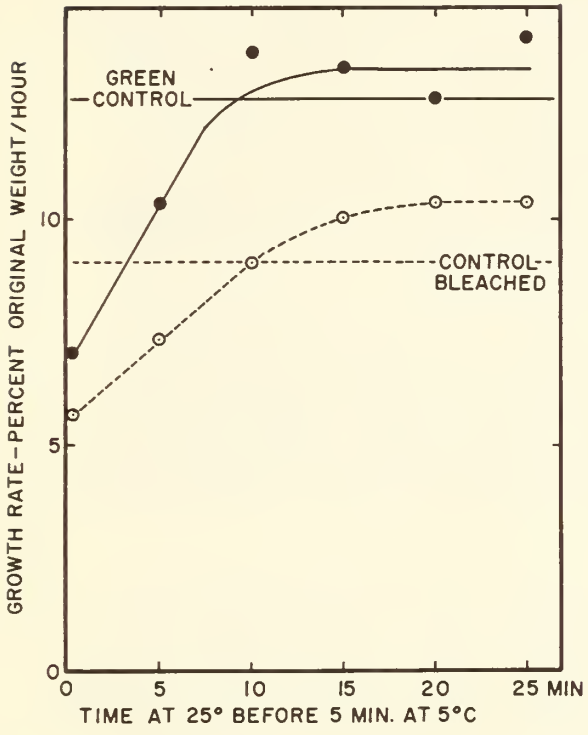

Figure 4.--Effect of imbibition at 25° C. in protecting excised lima bean axes against chilling injury. Figure from (5).

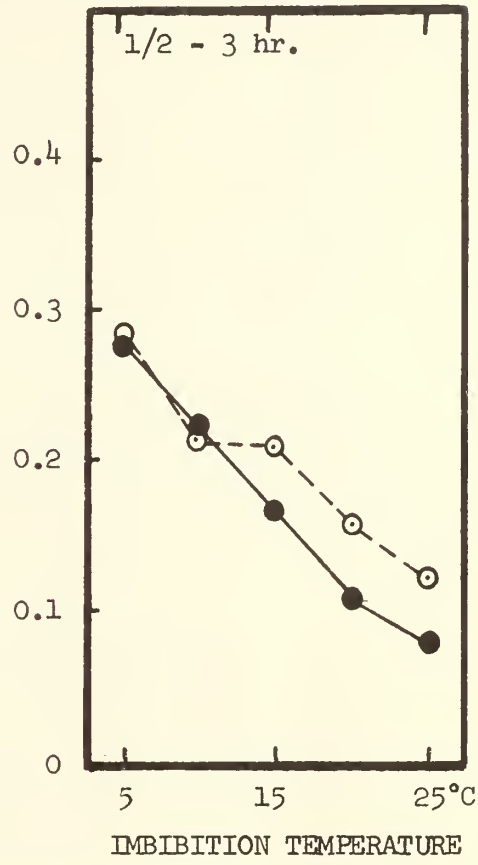

Figure 5.--Leaching of UV-absorbing materials from excised lima bean axes during the period 0.5 to 3.0 hours from beginning of imbibition.

Use of the excised embryonic axis system led to the discovery of a time-specific, temperature-sensitive period during imbibition. It also provided objective evidence of the difference in vigor between bleached and green seeds, because growth of axes from bleached seeds was always less than that of axes from green seeds (figs. 3 and 4). This provided a quantitative measure of what lima bean producers had subjectively recognized, that bleached seeds are less vigorous than green seeds.

We examined the water in which axes were growing and found that temperature injury caused a leakage of organic materials absorbing at 260 nm. and hence tentatively identified as "nucleotides." The relationship between amount of leachate and temperature injury was established before growth of the axes (fig. 5), suggesting a cause and effect relationship.

Existence of an inverse relationship between seed quality and leakage of organic and inorganic materials is well established in seed physiology. The relationship between loss of organic nutrients by roots and seeds and the stimulation of organisms in the soil microflora is also well established. Therefore, it seemed logical to assume that in the soil imbibition temperature injury might stimulate pathogenicity of soil microorganisms toward the germinating seed. If this were true, then measures to reduce imbibition temperature sensitivity might be expected to minimize the necessity for chemical seed treatments.

To test this hypothesis, a research contract was negotiated with Cornell University. D. F. Bateman of the Plant Pathology Department performed enough experiments to suggest that the hypothesis is valid (10). Unfortunately, the project was a victim of budgetary cuts and the potential for minimizing the use of chemical treatment of seeds could not be fully explored.

To study the mechanism of imbibitional sensitivity, my colleague, Eric Roos, studied (9) the relationship between axis growth and the development of the enzyme RNAse. He compared the effect of submerging the axes in water during initial imbibition with the effect of imbibition on the surface of moist filter paper. He found that submergence for even the first 10 minutes could have a long-term delayed effect on both growth and enzyme development (table 1).

TABLE 1.--Effect of initial submergence of axes on subsequent growth and development of ribonuclease activity in lima beans
(Crop Sci. Accepted for publication July 1970.)

Time submerged	Growth[1/]	RNAse development[1/]
	Percent	Percent
Control	100.0[1/]	100.0[2/]
10 minutes	83.7	37.2
30 minutes	90.1	48.9
60 minutes	73.4	37.7
120 minutes	78.2	48.9
180 minutes	70.7	39.0
18-1/2 hours	0.0[1/]	0.0[2/]

[1/] Absolute values = 373 and 192 (Percent increase over initial axis weight). [2/] Absolute values = 0.353 and 0.122 (Δ O.D./hour).

However, the effect of initial submergence on enzyme development was much more pronounced than was the effect on growth. This result emphasizes the conclusion that events during the initial stages of imbibition can have a long-term effect on axis development.

When intact axes are placed directly in liquid water, the outer cells become hydrated very much more rapidly than the inner cells. This produces a mixed cell population with different hydration levels. Thus we could not relate imbibitional temperature sensitivity to cell water content. To avoid this problem, I allowed axes to absorb water in the vapor form, on the assumption that vapor uptake would be slow enough to approximate moisture distribution within the axis (6). When this was done, I was surprised to find that only a relatively small increase in axis moisture content was enough to eliminate chilling injury (fig. 6). The effect was completely reversible; the

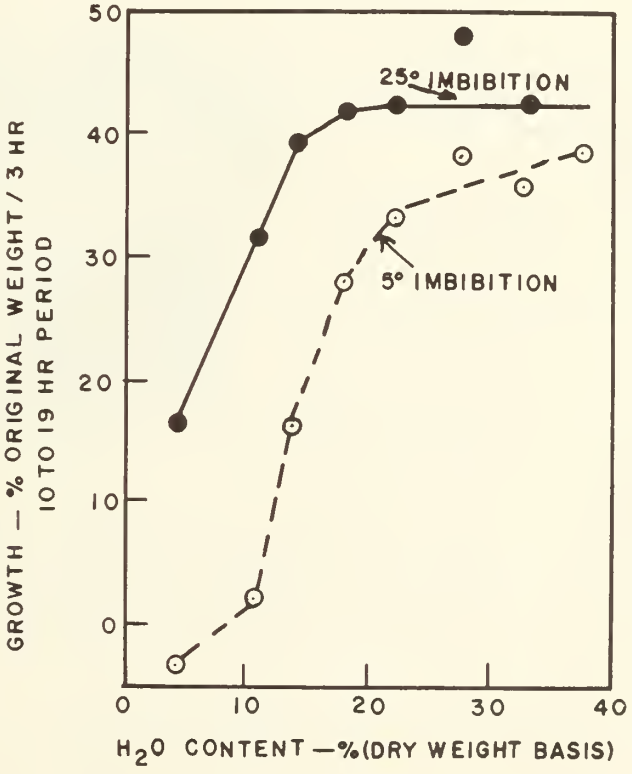

Figure 6.--The effect of axis water content at the beginning of imbibition of liquid water on imbibitional temperature sensitivity. Data from (6).

response to chilling injury was determined by the moisture content of the axes at the time that the uptake of liquid water began (fig. 7).

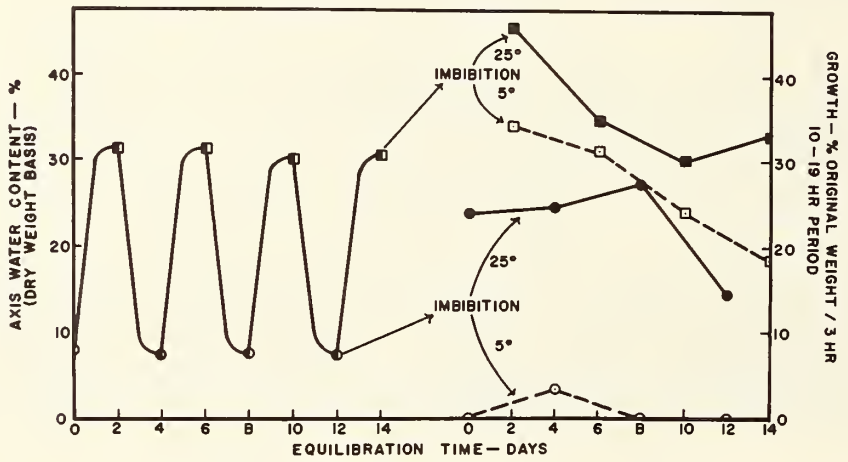

Figure 7.--Data showing that imbibition temperature sensitivity is determined only by the water content at the beginning of imbibition (6).

Thus, from this series of experiments with excised embryonic axes, we were able to conclude:

(1) The beginning of the imbibition period of germination is an especially critical stage in axis growth.

(2) The important factor is axis moisture content at this time. Imbibition temperature sensitivity can be eliminated by increasing axis moisture.

Although these concepts originated from basic experiments with excised axes rather than with whole seeds, we found them to be directly applicable to germination of whole seeds. Low vigor (bleached) lima seeds are much more sensitive to imbibition temperature than are green seeds (5) (fig. 8). Although the time scale for whole seeds differs from that of excised axes, the data show that seeds are sensitive to chilling injury only at the beginning of imbibition (fig. 9). The data are applicable to both lima (5) and garden beans (8); increasing seed moisture before imbibition eliminated imbibitional temperature sensitivity.

This spring we tested the effect of seed moisture on stand establishment under field conditions. My colleagues,

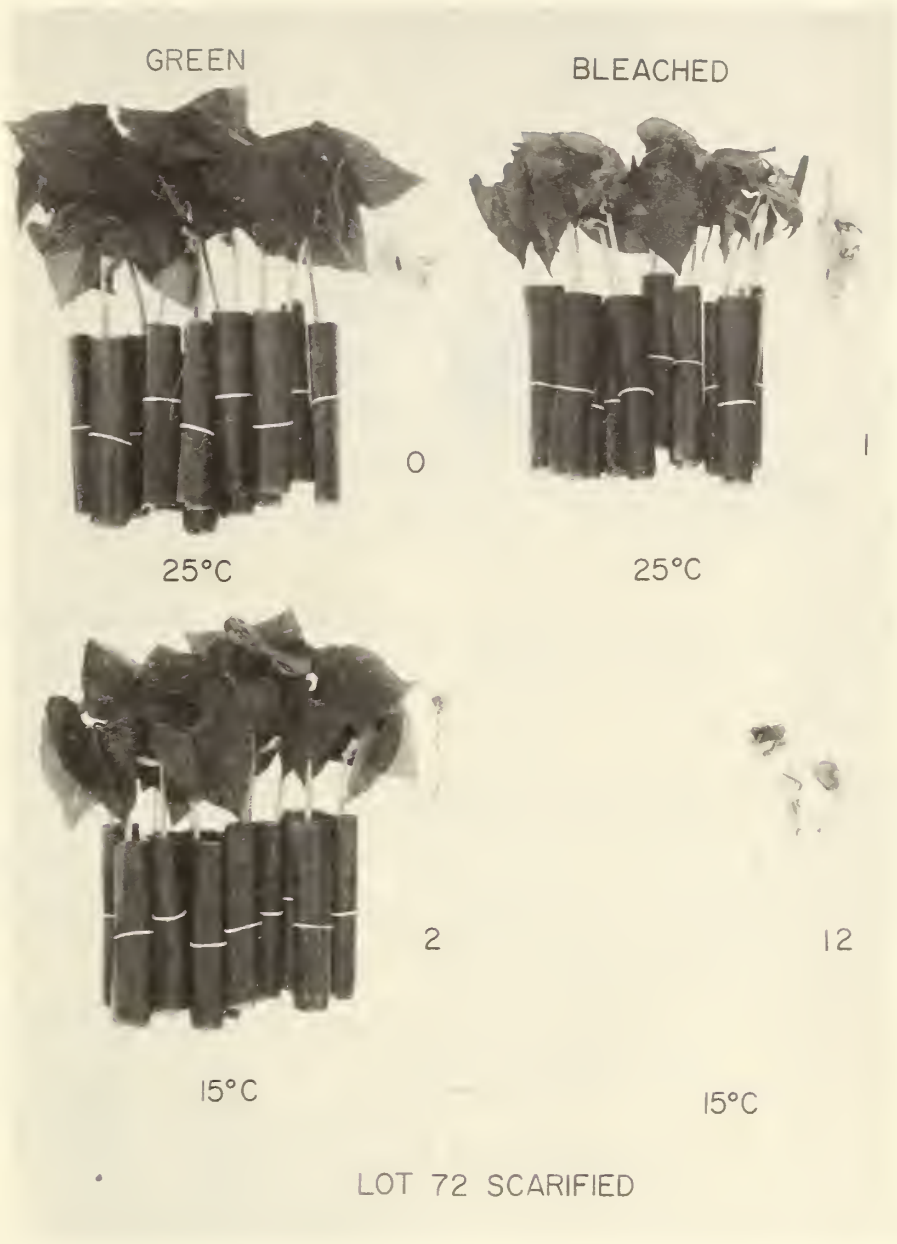

Figure 8.--The difference in response of high vigor (green) and low vigor (bleached) lima bean seeds to imbibition temperature injury. The number at the right of each group indicates the number of seeds decaying from a 15-seed sample.

Figure 9.--A short imbibition period at 25° C. preceding 18 hours at 15° C. shows that the temperature-sensitive period in whole lima bean seeds is approximately 6 hours. Figure from (5).

Joseph Manalo and Eric Roose, planted two lots each of White-seeded Tendercrop and Kinghorn Wax garden beans at each of two moisture levels. The planting was followed immediately by the application of 1 inch of irrigation water from sprinklers. That night we had a late spring freeze. Figure 10 shows the temperature of those seeds

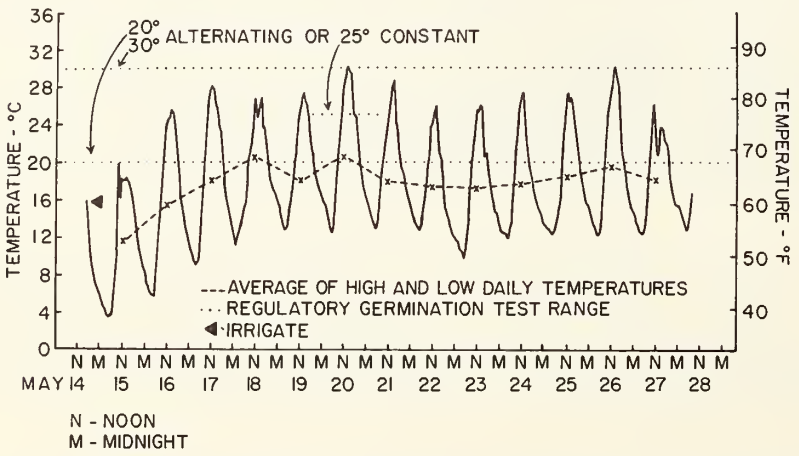
20°
30° ALTERNATING OR 25° CONSTANT
TEMPERATURE - °C
TEMPERATURE - °F
---AVERAGE OF HIGH AND LOW DAILY TEMPERATURES
···REGULATORY GERMINATION TEST RANGE
◀IRRIGATE
N M N M N M N M N M N M N M N M N M N M N M N M N M N M N M
MAY 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
N - NOON
M - MIDNIGHT

Figure 10.--Daily temperature fluctuations of garden bean seeds germinating in the soil near Fort Collins, Colo., in 1970. Survival data are presented in table 2.

throughout their germination. You will note that the field germination temperature, which can be considered normal for early planting, was very much below the temperature under which seeds are normally tested in the laboratory.

After the seeds had germinated and the seedlings had emerged, the number of seedlings emerging was counted. The data are shown in table 2. You can see that for all seed

TABLE 2.--Effect of initial seed moisture on emergence of early planted garden bean seedlings

Variety	Lot number	Seed moisture	Emergence
		Percent	Percent
White-Seeded Tendercrop	70.1	8.8	38.3
		13.1	70.5
White-Seeded Tendercrop	70.2	8.7	17.7
		13.2	54.2
Kinghorn Wax	70.5	8.6	33.2
		11.2	55.7
Kinghorn Wax	70.6	8.7	31.0
		11.7	68.0

lots tested, the effect of increasing the seed moisture was to approximately double the number of emerging seedlings.

In the laboratory, we test seeds using imbibition temperature and oxygen content of the germination medium as stress factors (7). In this field experiment, we had an additional stress due to crusting of the soil. Early germinating seeds, those with high moisture, largely avoided damage from crust development.

Others have recently noted similar phenomena in cotton (1), sorghum (4), and soybeans (3), suggesting that we are dealing with a general biological phenomenon of potential importance to agriculture. We have recently been looking at dry beans, and our preliminary data suggest that plant establishment in dry beans also may be influenced by these environmental factors. Our interest in dry beans was originally stimulated by the work of Dexter (2) who suggested that increasing seed moisture to above 12 percent would minimize mechanical damage during planting. He found that

increasing seed moisture from approximately 11 to 16 percent approximately doubled seedling emergence (38.7 to 77.8 percent). He attributed this effect to a decrease in seed breakage during planting. However, his data show no appreciable difference in number of abnormal seedlings (2.5 to 1.3 percent).

The breaking of dry seeds during planting is a well-known phenomenon. Unfortunately, the failure of treatment effect to appear in the number of abnormal seedlings makes it impossible to determine whether the observed increase in emergence was the result of reduction in mechanical damage or the result of the elimination of imbibition temperature injury.

Our preliminary results in the laboratory do not yet permit us to separate these two phenomena for dry beans. Our problem emphasizes the kind of difficulty to be faced by plant breeders and seed users in identifying and modifying the causes of low vigor in seeds. For example, the plant breeder might reasonably expect to select lines for high emergence under unfavorable germination conditions. However, to do this he would need to recognize the related effects of low seed moisture on both mechanical damage and imbibition temperature sensitivity. He would need to apply the appropriate stress to every generation at which he made selections. Only rarely have breeding techniques included application of such well-defined physiological stresses as a tool in selection for a desirable plant character. Perhaps in the case of bean breeding we now have enough available information to make this technique feasible.

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EFFECTS OF AIR POLLUTION ON THE GROWTH AND DEVELOPMENT OF BEANS

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The presence of toxic substances in the biosphere is of interest and concern to us because such compounds pose a direct hazard to man and because they constitute a threat to the maintenance of a biosphere suitable for life. Biological evolution has resulted in closely integrated, structured systems, in which populations exist in definable quantitative relationships to each other. These systems are not static but are subject, on a time scale very long compared with a human lifespan, to a continued augmentive change through evolution; on a shorter time scale, the systems are subject to succession. These evolution-ecosystems have been the dominant influence on earth throughout the span of human existence. Now, as pollution becomes more prevalent, the structure of these systems is changing, and we know well that in the next decades we cannot look to evolution to cure the set of problems posed by pollution. We can begin to speculate on where continued, exponential progress in this direction will lead: probably not to extinction - man will be around for a long time yet - but, discouragingly, to a general degradation of the quality of life.

The Nature of the Problem

Our concern at this time is with air pollutants, and particularly with the injury to crop and ornamental plants which results from exposure to these pollutants. The magnitude of the economic loss is staggering and, pertinently, about one-fourth of the crop loss occurs in California. Of that, the damages in the Los Angeles area alone range upward of $5 million yearly. The incidents of injury are more frequent, although generally less severe, than those associated with the smelting of ores earlier in this century. The

1/ I am indebted to my collaborator in zealous research, Prof. A. C. Leopold of Purdue University. His generous assistance in terms of time and facilities enabled me to compile the information included in this paper.

severity of damage in bean crops, and in some other crops as well, has been reduced to some extent by grower's selection and by propagation of resistant plants showing the least injury; damaged plants are often automatically eliminated, even though the cause of injury may not be known.

Most of the crop loss which occurs is due to the suppression of growth or to chronic injury. Evidence that such modifications in the appearance of plants are brought about by air pollutants comes from comparisons in laboratory and field studies of the relative growth of plants in carbon-filtered and unfiltered air. One of the most sensitive and most widely grown test plants in this connection is the bean. For the past 25 years, the pinto bean has been frequently used as a bioindicator of smog sensitivity; it and other beans are also widely employed in studies of other atmospheric pollutants, including ozone, peroxyacetyl nitrate (PAN), ethylene, sulfur dioxide (SO_2), and fluorine compounds. The nature of the injury which bean plants sustain suggests the nature of the pollutant; i.e., each pollutant tends to produce a particular pattern of damage, leaving on the plant a graphic, visible record of air pollution episodes. Additionally, the extent of the injury is determined by genetic and environmental factors and also by the level and duration of exposure to pollutants.

Currently, the two most commonly used pollutants in experimental investigations in laboratory and in some field studies are ozone and PAN. The former is a natural component of the upper atmosphere, present in greater amounts following electrical storms. It can be produced in this atmosphere by photo reactions involving oxides of nitrogen which react with oxygen, and hydrocarbons from cars are particularly effective in this regard. The second commonly used pollutant, PAN, was identified about 8 years ago as one of the most toxic smog components. Interestingly, it appears to be a component of west coast smog; it has not been identified as a smog component elsewhere. It is produced as a reaction product of simple olefins and nitrogen oxides; the sources of olefins are primarily exhausts from cars and trucks.

Growth Modifications Associated with Ozone and PAN

In laboratory and field studies certain typical morphological modifications have been noted in bean plants fumigated with ozone or with PAN. Generally, the laboratory treatments are of relatively short duration and the dosage of ozone or PAN is relatively low. For example, 0.1 to 1.0 p.p.m. of ozone exposure for about 2 hours is sufficient

to induce typical structural aberrancies in leaves. Typical symptoms have been noted and a comparison of some morphological responses of bean leaves exposed to ozone and PAN is as follows:

OZONE	PAN
1. Mature leaves most sensitive	1. Young leaves most sensitive
2. Less growth inhibition	2. Greater growth inhibition
3. Necrotic flecking on upper leaf surface	3. Silvering or bronzing on lower leaf surface
4. Lesions confined to upper surface	4. Lesions present on lower surface
5. Development of red-brown pigmentation and some cell wall thickening	5. Glazing of leaf surface; leaf appears very thin
6. Light-yellow to white flecks, indication of collapse of palisade cells; general chlorosis	6. Inhibition of seed germination

Mature bean leaves are most sensitive to ozone; young leaves are most sensitive to PAN. This is a particularly interesting observation because it tends to negate the once widely held premise that the stomates (pores) on leaves must be open for most kinds of smog damage to occur. In fact, the response to ozone or PAN is not related to stomate opening (on very young leaves stomates may not even be fully developed, let alone open) but, rather, is related to leaf age.

Correlated with leaf age sensitivity is the observation that PAN results in a greater inhibition of overall growth than does ozone. This is quite possibly related to the severity of PAN damage on young leaves and the resultant early induction of growth modification.

The visible effect on bean leaves involves a necrotic flecking of the upper leaf surface following ozone fumigation (fig. 1A), and a silvering or bronzing of the lower leaf surface after treatment with PAN or SO_2 (fig. 1B). Lesions are confined to the upper surface of ozonated plants, but may spread to involve both the upper and lower surface of

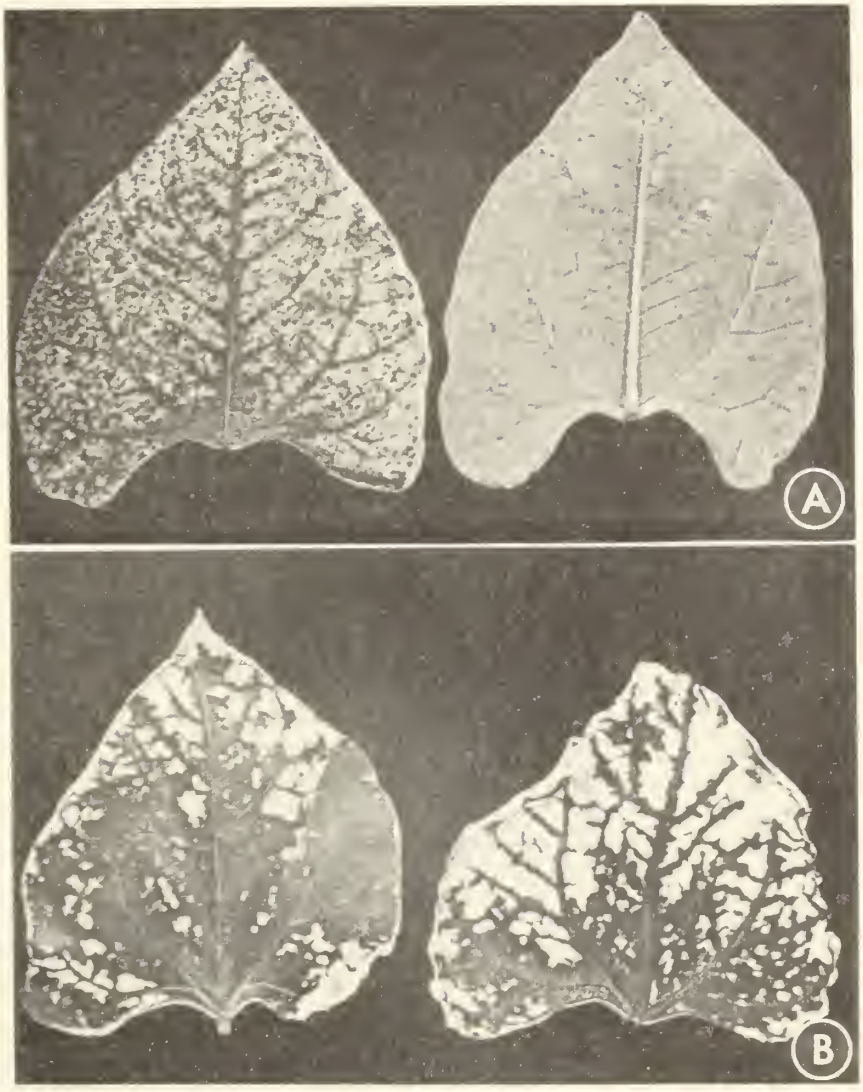

Figure 1A.--Primary leaves of bean plant exposed to ozone fumigation. Upper surface (left) of leaf shows typical localized necrotic regions, which result in a flecked appearance of the leaf. Lesions appear to be confined to the upper surface of the leaf, with very little evidence of damage on the lower surface (right) of the leaf. Photo adapted from Hill and others, 1961.

1B.--Primary leaves of bean plant exposed to PAN or SO_2 fumigation. Both the upper surface (left) and the lower surface (right) of the leaf show the typical silvery, glazed, delicate appearance associated with this type of treatment. Photo adapted from Brandt and others, 1968.

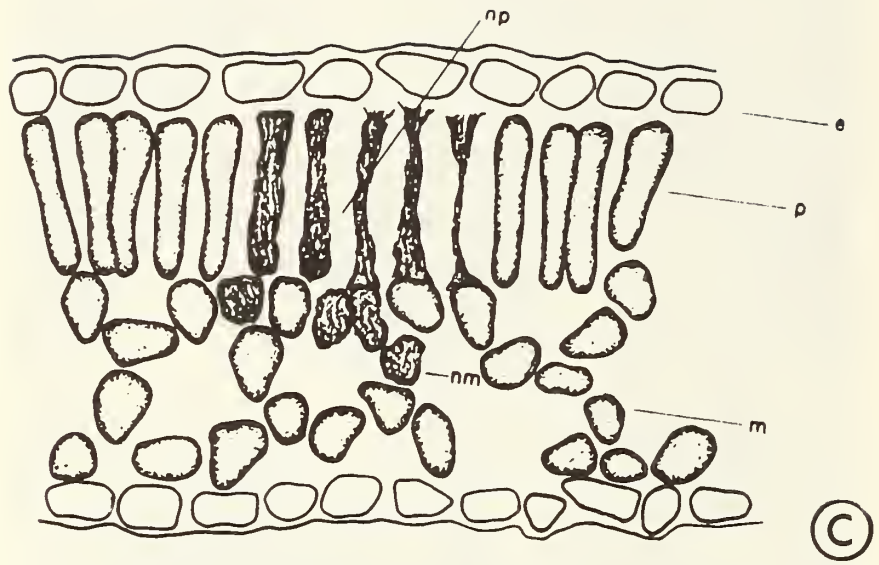

Figure 1C.--Transection of a typical bean leaf, illustrating cellular damage after exposure to ozone. The upper and lower epidermis (e) remain intact, and some chlorophyll-containing palisade (p) cells and some mesophyll (m) cells are undamaged. Note particularly the localized damage to certain palisade and mesophyll cells resulting in collapse and necrosis of palisade and mesophyll (np and nm).

PAN-treated plants. The flecking associated with ozone exposure appears to indicate a collapse of the chlorophyllous palisade cells beneath the epidermis (fig. 1C) and the development of localized chlorosis. Occasionally, in ozonated plants, a red-brown pigmentation appears, and some cell walls become thickened. After PAN or SO_2 treatment, on the other hand, the silvery, glazed leaves appear delicate and very thin (fig. 1C).

Although morphological modifications often sharply define the particular nature of the pollutant, it is interesting that many physiological changes result in similar changes following exposure of bean leaves to ozone and PAN. A comparison of some physiological responses of bean leaves exposed to ozone and PAN is as follows:

OZONE	PAN
1. Increase in permeability of cell membranes	1. Same
2. Blocking and retardation of starch hydrolysis	2. Same
3. Decrease in CO_2 fixation	3. Same
4. Inhibition of mitochondrial activity	4. Light necessary before, during, and after treatment
5. Inactivation of IAA	5. Inhibition of cell expansion

Both ozone and PAN increase the permeability of cell membranes, both decrease CO_2 fixation, both inactivate indoleacetic acid, and both block or retard starch hydrolysis. In addition, ozone inhibits mitochondrial activity, and PAN inhibits seed germination and cell expansion.

Any of these morphological or physiological modifications could be elaborated upon at length with a view to achieving a greater understanding of some of the basic mechanisms of action of various regulatory compounds involved in the induction of pollutant effects. As an example, we have selected to discuss briefly the problem of CO_2 fixation. This ordinarily takes place in the chloroplasts, in the structural component known as the stroma. Ultrastructural studies recently carried out by Thomson, Dugger, and Palmer on PAN-treated leaves of Phaseolus vulgaris cv. Black Valentine indicated the presence of small electron dense granules in the stroma. After PAN fumigation, the granules increased

in number and assumed a crystalline appearance. The shape of the chloroplast was altered as the number of granules increased. Granules then appeared to fuse into rods and subsequently into organized plates. The membrane surrounding the chloroplast was disrupted and cell contents became clumped. Plates continued to develop through the gradual degradative stages of the cells. Such developmental changes as these in the stroma of chloroplasts may well play an important rule in inhibiting CO_2 fixation and thereby limiting the photosynthetic capacity of the bean leaves.

The question may well arise at this point as to just what can be done to control pollutant damage. The most obvious approach is to control the dissemination of air pollutants. How successfully this can be done at the present time is a moot question. Genetic control is within the realm of possibility; and the breeding and development of resistant varieties, in programs now being carried on by Carl Tucker at Davis, show considerable promise. From a physiological point of view, the possibility exists that control can be exerted over the action of certain growth regulators. For example, it is known that indoleacetic acid (IAA) is inactivated by oxidant pollutants; thus many aspects of the growth of the bean plant are interfered with. Periodic renewal of IAA might reactivate plant growth. Perhaps IAA inactivation could be prevented by the application of ascorbic acid and glutathione. Although it is known that ascorbic acid protects against IAA inactivation, it cannot restore IAA activation once the IAA is destroyed. The application of vitamin C to roots and leaves of beans has been shown to increase tolerance to ozone fumigation. Field trials in the Los Angeles area indicate that spraying with K-AA is effective in this connection, but less than 1 percent of the spray is absorbed by the leaves. It is questionable, however, how effectively such a technique could be employed on a large scale and throughout the entire growth period of the bean plant.

Summary

Toxic substances in the atmosphere are often hazardous to man and may also constitute a threat to the maintenance of a biosphere suitable for life. Structured ecosystems, in which populations have evolved throughout the span of human existence, are subtly modified as air pollution becomes more prevalent. As the structure of these systems changes, the gloomy prognosis suggests a general degradation of the quality of life.

At the present time, air pollution damage accounts for one-fourth of the crop loss in California. Experimental studies of the nature of pollutant effects have been frequently carried out on various varieties of beans because these are among the most sensitive bioindicators of the most common atmospheric pollutants. It is particularly interesting that the nature of the injury which bean plants sustain suggests the particular nature of the pollutant. For example, ozone, peroxyacetyl nitrate (PAN), ethylene, sulfur dioxide (SO_2), and fluorine compounds each produces a unique pattern of damage, leaving on the bean plant a graphic, visible record of the particular air pollution episode.

Some of the most typical morphological modifications of bean growth which result from pollutant exposure include flecking of the leaf surface; silvering or bronzing of leaves; breakdown of chlorophyll-containing cells; and leaf and flower drop. Physiological modifications include a loss of the selective permeability of cell membranes; a decrease in carbon dioxide fixation; an inactivation of the growth hormone indoleacetic acid (IAA); and a blockage or retardation of starch hydrolysis.

Investigations designed to alleviate air pollution damage to beans presently involve studies of the control of the dissemination of air pollutants; the breeding and development of resistant bean varieties; the periodic renewal of growth hormones by spraying; and the direct application of certain compounds known to increase the tolerance of beans to pollutants.

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EFFECT OF PLANT POPULATION AND DISTRIBUTION ON THE PRODUCTION OF DRY BEANS FOR SEED IN IDAHO

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There is considerable information about varied plant population or "high density" plantings available to us from scientific journals and from the trade magazines. The Advances in Agronomy, 1963, has a very comprehensive article by C. M. Donald of Australia entitled "Competition Among Crop and Pasture Plants." The American Vegetable Grower Magazine discussed the effects of plant population on 17 vegetable crops in its October and November 1968 issues. Fresh snap and lima beans were among the crops considered. In every case, yields were increased from a little to as much as 50 percent by higher plant populations, and lima yields were almost doubled by a system of double rows 12 inches apart in Mississippi.

Work by Burke and Nelson at Prosser, Wash. (1) indicates that higher yields of bean seed can be expected in narrow rows than in wider rows at a given plant population per square foot. They also showed increased yields with plant population increases from 1 to 9 plants per square foot under adverse growing conditions, specifically when root rot was severe; however, under more favorable conditions 1 to 2 plants per square foot gave the highest yield of field bean seed. Workers in Canada (2) showed in reviewing other work and reporting their own that soybean seed yields increased in narrow rows as the spacing between the plants was increased. There are reports of corn and sorhgum yields being increased as rows are narrowed even though seeding rates are not increased in proportion to the narrowing of the rows.

H. J. Mack, Oregon State University reports big yield increases (45 percent) for bush snap beans with 6 X 6-inch and 5 X 5-inch spacings when compared with 12-, 24-, and 36-inch rows. The Idaho Experiment Station at Kimberly has done some work with bush snap and dry beans for seed that has shown increased yields up to 20 percent but usually 10 to 15 percent by using varied plant spacings.

All of these reports seem to present one concluding fact; the spacing of plants so that they are more nearly equidistant one from the other has improved not only the per acre yield but also the vigor of the plant involved.

The same or slightly higher plant populations than those formerly used have been redistributed to produce these advantages.

Higher fertility levels at the present populations are not producing continuously greater yields, so the plant population change is one way to improve yields. In southern Idaho a large acreage is devoted to bean seed production for seed as well as dry-edibles, but not bush snap or green beans. This seed is produced under irrigation where moisture as well as nutrition can be controlled, which is also true for most of the bean production in the western United States. Idaho growers normally use a 22- or 24-inch row spacing and a 2-inch spacing within the row for snaps and a 3-inch spacing for dry beans. Closer spacings of the plants within the 24-inch row does not improve yield or quality and likewise wider spacings within reason have not been deletorious to yield.

Broadcast seeding or patterns approaching the 6- X 6-inch scheme have given the highest yield but create some problems for our growers in irrigation, weed control, and harvest. None of these problems are beyond solving but if it requires much expense to change, greater returns must be in sight for the grower. At least one cultivation seems to be necessary to put a ridge of soil around the plant to encourage secondary root systems in a root-rot environment. There may well be both bush and semivining varieties of beans on the same farm. Therefore a population density greater than that now used in Idaho but less than Harry Mack's 6 X 6-inch spacings should allow the "competitive density effect" or "equidistant spacing" to improve seed yield and still be workable.

Idaho growers who have changed are using row spacing combinations like 16 inches between all rows or 14-20-14-20 and increasing planting rates from two plants/square foot (75#/A) to as much as 4 plants/square foot (145#/A). This is as high a seeding rate as the experiment station at Kimberly will recommend at this time.

This same philosophy should apply to most of the irrigated bean-producing areas of the western United States with slight modifications to fit local conditions, and growers should be encouraged to try.

A quality factor of importance to the Idaho bean seed industry is uniform seed size, which can be improved by

proper use of the subject under discussion here. A second factor is maturity and plant vigor; closer spacing of plants reduces the vigor of the individual and hastens maturity.

This effect is often used by our bean seed production people in Idaho. Figure 1 will give some yield trends for two areas.

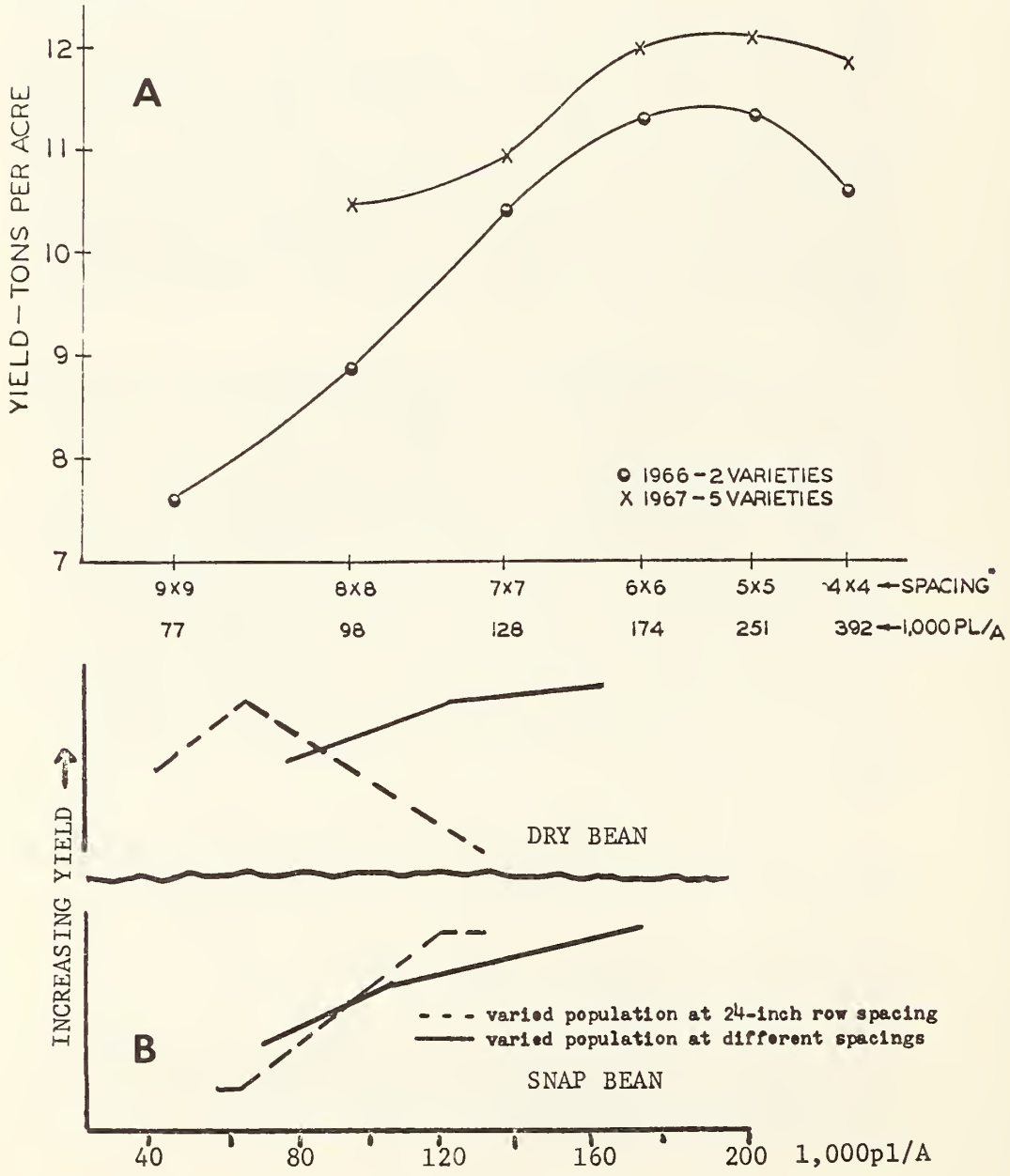

Figure 1.--Yield trend of bush snap beans in Corvallis, Oreg. (A) and of dry and snap beans at the University of Idaho, Kimberly (B).

When one discusses this subject, there are several key words used, such as: high density planting, plant population, equidistant spacing, optimum and maximum plant density, square vs. triangular arrangements, concentration of yield, plant vigor, and maturity. In summary we might say: The yield of many crops is increased and maturity and vigor are controlled by using the high density technique which results in the plant populations being spaced more equidistant in a square or triangular arrangement so that the maximum plant density used to produce these effects then becomes the optimum density.

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THE REVOLT OF THE CONSUMER

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I've been helping the consumer revolt develop over the past 15 years while acting as a "consumer consultant" in a large supermarket. The pace of the revolt is accelerating. Consumers are particularly concerned about hazards in their food. This, in turn, results in the press giving greater coverage to consumer issues.

About 10 years ago the Association of California Consumers was formed to band together both individuals and groups concerned about consumer representation in Sacramento and Washington. At about the same time, Helen Nelson was named by Governor Brown to the post of consumer counsel for the State of California, the first one in any of the 50 states. Somewhat later we had Esther Peterson, then Betty Furness, and presently Virginia Knauer as special assistant to the President for consumer affairs in Washington. While consumer representation in government in California has backslid under Governor Reagan, we now have consumer representatives in several other state governments and one city, New York, has a commissioner for consumers. We have a national consumer organization, the Consumer Federation of America, which has members in about 40 states. And, maybe I should have named him first, we have Crusader Ralph Nader with his corps of young lawyers who has really shoved the consumer movement into high gear. The press and TV coverage of CFA's Consumer Assembly in Washington last January was truly impressive. It used to be consumer spokesmen had to work to plant a story - now the reporters look us up and beg for stories. Even the retail grocers through their trade associations are saying that if consumers really want unit pricing, for example, then they shall have it.

I want to call to your attention this afternoon one aspect of consumer concern which I shall call the "Attrition of nutrition" - meaning the grinding down of the nutritional content of foods by various processing techniques. I have gathered some excerpts from newspaper and magazine articles that illustrate the problem that concerns me. In the Co-op NEWS of June 15 we read: "Cool 'n Creamy - but what's in it? General Foods new line of frozen puddings, Cool 'n Creamy, has taken over

top spot in the pudding market within the past four months. What's in it? Read the label: water, sugar, nonfat dry milk, vegetable oil, modified food starch, cocoa, emulsifiers, vanilla extract, sodium caseinate, dextrose, salt, artificial color and flavor, calcium carrageenin and guar gum. The ingredients are listed in order of weight or volume, but there is no law requiring that the actual amounts of water, etc. be listed. Which is why there is a movement now afoot to require the most valuable ingredients in a food to be listed in terms of percentage on the package."

In CONSUMER REPORTS for June 1970, we find this question: "Is good frozen pie just pie in the sky? In a report on frozen fruit pies last October, CU waxed something less than enthusiastic over almost all the pies we tested. They contained too little fruit and too much filler to taste anything like home-baked pies. Industry comment on our report was quick and predictable: CU's standards are too high; all commercial pies are made with about the same fruit content; it's impossible to mass produce a really good pie at a competitive price; and, anyway, the pies must be good enough or people wouldn't continue to buy them." And then the article goes on to report on a brand of commercial pies which CU tested after the report was published which contained TWICE the amount of fruit as found in most commercial pies and selling at prices very similar to those other short-on-fruit pies tested earlier. And, to make the point even sharper, the pies tasted like home-baked pies.

In May we see from the San Francisco Chronicle that Ralph Nader addressed the Institute of Food Technologists' annual meeting telling them that: "Never before have water, fat and air sold at such high (food) prices...the food industry has done wonders with camouflage - palatability, visual appeal, tenderness, and shelf life are all improved. But no self-respecting French housewife would...buy that conglomerate putty we call Wonder Bread. Why does a kid come out of a grocery store with a bag of potato chips and a Coke instead of a banana or an apple? Hundreds of thousands of kids are growing up concerned that Pepsi and Coke are essential prerequisites to human health and vigor. It's the soft drink-pretzel-Frito-Lay syndrome."

The food technologists didn't take very kindly to Mr. Nader, in fact, they were rude. And, to top it off, they gave their highest achievement award to the makers of

Cool Whip, "A stable freeze thaw whipped emulsion resembling whipped cream in appearance, utility and textural-flavor characteristics," according to the Chronicle for May 23. The writer could have added that, unlike whipped cream, Cool Whip contains no nutrients other than calories. The ingredients in Cool Whip are: water, hydrogenated vegetable oil, sugar, vanilla, sodium caseinate, dextrose, polysorbate 60, sorbitan monosterate, carrageenan, guar gum, and artificial color and flavor. Sounds like Cool 'n Creamy, doesn't it? Not only did Mr. Nader chide them about lowering nutritional qualities of foods but a distinguished British food scientist and president of the British Institute of Food Science and Technology, told them that "food manufacturers must accept the responsibility for providing high nutritional value in their products - and particularly so when individuals may soon be subsisting entirely on diets that come from the laboratories of food technologists."

Another eminent scientist, this time a Harvard nutritionist and head of the recent White House Conference on Food, Nutrition, and Health, Dr. Jean Mayer, criticized the baby food industry for replacing expensive and more nutritious components in their products with cheaper starches and sugar (HARPER'S, January 1970). In the November 25, 1969, issue of LIFE, Mayer is quoted as saying that "fried worms would be better than most snack foods in regard to nutritive content for you'd at least get some protein."

Some makers of snack foods may have bad consciences. I was a consumer representative on the Food Safety Panel of the White House Conference headed by Mayer. The chairman of my panel was Donald M. Kendall, president of Pepsi. Kendall was pretty upset when FDA banned cyclmates in the fall of 1969 but, when Mayer advocated worms, he resigned from the panel and the conference for "personal and family reasons," but rumor was that the real reason was annoyance with Mayer's worms.

One of the most recent blasts at the heartless food industry was directed at the breakfast cereal manufacturers by Robert B. Choate, a wealthy Republican, who probably knows more about the domestic hunger issue than any other businessman in America. He was director of community affairs for the White House Conference. While Choate doesn't know much about how nutritionists rate quality in cereals, he does believe that the breakfast cereal industry with both high profits and high advertising budgets has a responsibility to provide nutritious foods to those

consumers it brainwashes into buying its "sugar-coated crunchies." Like Rachel Carson and the environment, Choate may succeed in focusing attention on a very real problem where many nutritionists have failed to make any headway.

After the headlining of Choate's cereal evaluations, Art Hoppe in the San Francisco Chronicle of July 27 had a great time dreaming up a breakfast cereal he called "Ka-Zowees." "Ka-Zowees", according to Hoppe, are advertised on TV, naturally. They are also chocolate-coated Styrofoam flakes with no nutritive value and thus got the lowest rating of all by Choate. In order to counteract this terrible setback, the manufacturer decided to bring out "ALL NEW Ka-Zowees" in a Super-Jumbo box, with a 19-cents-off deal and two free offers on the back. Each box contains 27 surprise prizes, and a full cubic foot of fresh air because, with all the prizes, new box, and free offers, the company couldn't afford to make Ka-Zowees nutritious so the problem was solved by omitting the product completely.

Things have gotten so bad in the fruit juice department that companies promoting products containing 100 percent orange juice, for instance, can use this type of ad copy: "Knudsen Real Orange Juice Comes on Strong on KFIO Radio, 640 Southern California. (It) is the only refrigerated orange juice made from 100 percent pure Valencia oranges with no sugar added. Not a watered down blend. Stock Knudsen Real Orange Juice for the unprecedented consumer demand for a real orange juice created by this strong consumer advertising campaign." This ad appeared in the FOOD MART NEWS of July 1970 and was addressed to the managers and operators of supermarkets who know better than the consumers that some orange drink products contain as little as 5 percent orange juice and few contain more than 30 percent orange juice. The diluted products sell for about the same price per pint as frozen orange juice concentrate.

The various recent surveys of the amount of malnutrition in this country are revealing much more extensive evidence of poor quality in our diets than most of us, including the nutritionists, were willing to believe might exist. This "hidden hunger" affects more than the low income segments of the population. Figures released by the U.S. Department of Agriculture for 1965 relating the nutritional quality of the diet to income are as follows:

INCOME	PERCENT WITH POOR DIETS
Under $3,000	36
$3,000-5,000	24
$5,000-7,000	18
$7,000-10,000	12
$10,000 plus	9

We know it's not only the poor that are malnourished to some extent. A survey of the food habits and physical conditions of teenage girls in Berkeley revealed that some had diets low in iron, ascorbic acid, and certain B vitamins. No breakfasts, poor lunches consisting of snack foods, and limitation of calories in order to remain slim were some of the reasons for the poor diets.

In the California legislature this year, Senator Lewis Sherman is carrying a compulsory enrichment bill that will require the four important nutrients lost when cereal grains are milled to be restored according to Federal standards when these milled grains are used as components of foods sold in retail stores. This is a kind of "motherhood" bill and so far has had no opposition from food processors or retail grocers. It has cleared the Senate and is presently ready to be voted upon by the Assembly.

I am very proud to tell you that the home economists employed by the Berkeley Co-op and the members of the Co-op's Consumer Protection Committee have been working for about 6 years to get this kind of enrichment bill through the legislature. If we succeed, highly milled cereals and foods containing significant percentages of refined cereal ingredients will be improved nutritionally. We were thinking of more than the middle class teenager with her snack foods. We were concerned that Oriental people who consume large amounts of white rice, Mexican-Americans who eat lots of cornmeal and rice; poor people generally who have to use a larger proportion of cereal foods because they are cheaper than meat; and all people who for various other reasons depend fairly heavily on cereals should not be lacking those nutrients that are lost in processing.

Generally speaking, the consumer has no voice in the economic decisions that affect him. Most protective laws are enacted as the result of some large-scale tragedy that has aroused the public to the need for better consumer protection. For example, the thalidomide episode and the amendment of the laws empowering FDA to regulate the production and marketing of drugs.

I would like to suggest that the bean growers, shippers, and processors attending this meeting adopt the principle that food values present in the raw food should be preserved in that food during processing and, if this is impossible, then the nutritionally significant ones should be restored.

I think we are moving in this direction in several areas. For example, FDA now permits nonfat dry milk to be fortified with vitamins A and D so that this inexpensive food can be recommended as the sole source of milk for children in low income families. FDA also has established regulations for the fortification of breakfast cereals and guidelines for foods that make low calorie claims on their labels. Unfortunately, some segments of the food industry as well as the drug companies are vigorously opposing the adoption of these regulations so it may take time and effort to secure these benefits.

You will find if you search through the Final Report of the White House Conference on Food, Nutrition, and Health (available from the Superintendent of Documents, U.S. Government Printing Office for $3.00), a number of recommendations directed toward the food industry in addition to those addressed to governmental agencies and Congress. These recommendations from experts in their fields should be used by all of us as guidelines for improving the nutrition of the American people.

I haven't been able to cull from the 341-page report all the recommendations that apply to the food industry but let me list some of them. In most instances, each recomendation was made by more than one panel.

(1) List the percentages of the major ingredients in the food on its label. For foods having standards of identity, list all the ingredients as well as the percentages of the principal ones.

(2) Key foods should be enriched or fortified with nutrients that are appropriate. Such decisions should be made by expert panels which would continuously review both the state of nutrition of the American people and the nutritional adequacy of the food supply. In order to accomplsih this, there must be nutritional monitoring of the food supply and continual surveillance of the health of the population as affected by diet.

(3) Minimal nutritional qualities must be assured for those new foods used by the public as a significant part of the diet.

(4) Food manufacturers and distributors should provide accurate nutritional information to consumers of their products, including information on labels and in advertising. The food industry cooperating with nutritional scientists should work out a method for tagging foods that have high nutritional content. Food distributors should use "their special talents" to promote the consumption of foods with high nutritive values. Fifteen percent of food advertising budgets should go for public service nutritional ads.

(5) Quality expiration dates (calendar dates) and other techniques for handling perishable foods that will help to preserve the nutrients until the food is eaten by the consumer. (Frozen foods, dairy products, lunch meats, etc.)

I don't believe that a concern for the welfare of society as a whole is limited to persons in the fields of social service and public health. I think food growers, processors, and distributors can be equally concerned with the public good. And from our experience in the Berkeley Co-op of trying to provide accurate consumer information and to merchandise our stock so as to not mislead the shopper, this kind of ethic can be very good for business.

THE FOOD STAMP PROGRAM AND ITS ROLE IN FEEDING THE POOR

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The Food Stamp Program is one of the means by which low income households can obtain better diets. Another is the Commodity Distribution Program, commonly known as the Surplus Commodities Program. Both programs are administered cooperatively by the United States Department of Agriculture Food and Nutrition Service (FNS) and the state. One or the other of these Family Food Assistance Programs is available to all counties in the Nation. Under present law, an area may operate only one of these programs at a given time.

The Food Stamp Program was undertaken as a pilot program in several counties in 1961. As experience was gained, and the merits of this approach were proved, Congress enacted legislation making the Food Stamp Program permanent. The authorizing legislation is Public Law 88-525, commonly known as The Food Stamp Act of 1964. As stated therein, this Act. was passed "to strengthen the agricultural economy; to help to achieve a fuller and more effective use of food abundances; to provide for improved levels of nutrition among low income households;...and for other purposes."

The Food Stamp Program enables low income persons to improve their diets by permitting them to exchange their food money for Food Stamp Coupons worth more. The amount paid for Food Stamp Coupons is set by the Food and Nutrition Service and varies, depending upon household size and net income. Households with smaller income pay less than those with larger incomes. The amount of Food Stamp Coupons received, however, is uniform for all households of a given size. This amount is sufficient to purchase an Economy Food Plan, a low cost, nutritious diet. For instance, a household of four with an adjusted net income of $200 pays $54 for $106 in Food Stamp Coupons. This includes $52 additional food purchasing power or "bonus" Food Stamp Coupons. The USDA makes up the difference between the amount paid and the value received by the participant. The individual can use Food Stamp Coupons, much like cash, in any store authorized to accept them. With these coupons, he can purchase any food for human

consumption, except most imported items. The only imported foods which may be bought with Food Stamp Coupons are coffee, tea, cocoa, and bananas. Retailer and wholesaler food dealers redeem the coupons, at face value, through their banks. The banks, in turn, forward the coupons to a Federal Reserve bank for disposition.

Eligibility requirements for Food Stamp Program participation are established by the state agency responsible for administering the federally aided public assistance program and are approved by the USDA, FNS. These standards must be related to the State welfare assistance standards.

Today there are approximately five and one-half million low income persons in 44 states and the District of Columbia using Food Stamps. They are paying about $54 million for more than $134 million in Food Stamp Coupons, including approximately $80 million in "bonus" Food Stamp Coupons. The most dramatic and direct impact of the Food Stamp Program, of course, is felt by those who use Food Stamp Coupons. However, since Food Stamp Coupons are expended through the normal channels of trade, you can see that the food industry, farmers, and the community in general also benefit from this Program.

While the Food Stamp Program can provide the means to eliminate poverty-related hunger and malnutrition, the existence of the Program does not in itself solve the problem. Those who need this Program must be made aware of its existence and its benefits. And those who are participating in the Food Stamp Program often need nutrition and consumer information in order to obtain full advantage from their increased purchasing power. Dry beans are versatile and comparatively low in cost. Perhaps more importantly, they can be utilized as extenders or alternates for more costly food items. In short, they can be of special significance to the food stamp homemaker. Our goal is to erase the hunger and malnutrition produced by economic status. You in the food industry, and possibly in this industry in particular, have much to contribute and much to gain. We hope you will join us in this endeavor.

CONSUMER USE OF DRY BEANS, PEAS, AND LENTILS

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Why don't people eat beans more often? To gain some insight into this question, a study was conducted among a sample of households in October 1969. Included was the consumption of dried beans and of the canned or frozen products made from these items. The survey was expected to develop preliminary information on three major points: (1) why are these items not consumed more often by persons with incomes above the poverty level; (2) at higher income levels, what are the characteristics of households which use large quantities of dry beans, peas, and lentils as compared with those which use small quantities of these items; and (3) what types of bean dishes and types of beans do persons in higher income households prefer? It was felt that this information would be of use to the Western Regional Research Laboratory in the development of their dry bean research program and to bean producers and processors interested in expanding the consumption of beans.

For this survey, a selected sample of personnel at the Western Regional Research Laboratory was asked to have the major cook of their households complete a questionnaire.[2/] Personnel directly related to the bean research programs were excluded. A good response was obtained; out of 156 questionnaires which were distributed, 153 were returned.

As part of the questionnaire, the respondents were asked to estimate the quantity of dry beans, peas, and lentils consumed in the household during the 6 month period before the survey. The purpose of the estimates was merely

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[1/] Economic Research Service economists are stationed at Western Utilization Research and Development Division to provide economic research services related to the development of the laboratory's current and future programs.

[2/] Statistical Reporting Services utilize a panel of 500 Washington, D.C., federal employees for product evaluations. Studies comparing the results achieved by this panel with results achieved by nonfederal families selected randomly indicates little or no difference in research findings.

to divide these households into high or low users of dry bean, pea, and lentil products. The estimates were not expected to be precise; however, they appeared to be fairly reliable. For example, the estimated per capita amount of about 5.5 pounds consumed by these households was similar to the per capita amount of about 6.0 pounds consumed by urban households with comparable incomes in the Western region as reported in the USDA publication, "Food Consumption of Households in the United States, spring 1965."

Tabulations of the responses obtained from the questionnaire were made by the following household characteristics: (1) ethnic group, (2) size, (3) composition, (4) sex of the major cook, (5) age of the major cook, (6) annual income, (7) whether or not the major cook worked, and (8) whether or not the major cook had been used to eating beans as a child. Tabulations were also made by (1) the frequency that beans, peas, or lentils were served and (2) the total quantity of beans consumed in a given period.

Of these tabulations, ethnic group and sex of the major cook were eliminated from consideration because of the small number of respondents in some of the categories. However, ethnic group should be included in further studies because, even with these small numbers, there appeared to be a relationship to bean consumption. Another variable which was eliminated was household composition. It was highly correlated with household size, and size appeared to be the more important variable in this study.

The only two household characteristics which were significantly related to the total pounds of beans consumed were: (1) as household size increased, the total quantity of beans consumed increased, as might be expected; and (2) if the major cook had been used to eating beans as a child and had liked them, she was more apt to serve them to her family than the cook who either was not used to eating beans or had disliked them as a child (table 1). The data showed that three-fourths of the major cooks had eaten beans as a child and had liked them (table 2). Of those cooks who either had not been used to eating beans when they were children or had disliked them, a significant number were the younger cooks.

The major reason given for not serving beans more often was "like other foods better" (table 3). A total of 45 percent of the households ranked this reason either first or second in order of importance. In the ranking of other reasons, about one-fourth of the households (25 percent) indicated that intestinal gas was a major problem,

TABLE 1.--Distribution of households by quantity of beans served in 6 months and by household size and experience of major cook with beans as a child[1/]

Quantity of beans served in 6 months	All household	Household size		Experience of major cook with beans as a child	
		One or two	Three or more	Ate beans and liked them	Not used to beans or didn't like them
Pounds	Percent	Percent	Percent	Percent	Percent
Less than 10	58	66	32	39	71
10 or more	42	34	68	61	29

[1/] Includes dry beans, peas, and lentils.

TABLE 2.--Distribution of households by experience of major cook with beans as a child and by age of major cook[1/]

Experience of major cook with beans as a child	All households	Age of major cook	
		Younger than 45 years	45 Years or older
	Percent	Percent	Percent
Ate beans and liked them	75	67	84
Not used to beans or didn't like them	25	33	16

[1/] Includes dry beans, peas, and lentils.

TABLE 3.--Distribution of households by reasons given for not serving beans more often by household size and by experience of major cook with beans as a child[1,2/]

Reasons for not serving beans more often	All households	Household size		Experience of major cook with beans as a child	
		One or two	Three or more	Ate beans and liked them	Not used to beans or didn't like them
	Percent	Percent	Percent	Percent	Percent
Like other foods better	45	54	38	34	79
Cause intestinal gas	25	26	24	27	18
Not in habit of cooking them often	18	21	16	17	24
Too long to prepare	15	13	16	18	5

[1/] Includes dry beans, peas, and lentils. [2/] Percentages will add to more than 100 because each percent includes those households which ranked the reason first or second in order of importance.

18 percent indicated that they were just not in the habit of cooking beans very often, 15 percent indicated that length of preparation time was a factor.[3/]

By household size, about one-half of the respondents in one- or two-person households indicated that they liked other foods better as compared with a little more than one-third of the respondents in the larger size households (table 3). It is possible that ease of preparation is an implicit consideration in this choice of reasons by the smaller household.

Almost four-fifths of the major cooks who, as children, had either not been used to eating beans or who had disliked them indicated that they liked other foods better. This compared with about one-third of the major cooks who had been used to eating beans as children and liked them. As to the other reasons, the cooks who, as was shown earlier, liked beans and served them more often were the most concerned with intestinal gas and length of preparation time.

Age of the major cook also appeared to be related to the reasons for not serving beans more often (table 4). Because the first and second choices were combined, statistical tests of significance could not be computed. However, a larger proportion of the younger cooks than of the older cooks indicated: 1) that they liked other foods better, 2) that they were not in the habit of cooking beans, and 3) that beans, took too long to prepare. A larger proportion of the older cooks as compared with the younger cooks indicated that intestinal gas was an important reason for not serving beans more often.

As to the type of beans that were served, kidney beans were served most often by the households in this survey, followed by garbanzo and white navy beans (table 5). As stated earlier, interpretation of these data by ethnic group must be made with care because of the small numbers in the categories other than "white," but there would appear to be a relationship between ethnic group and types of beans consumed at these higher income levels. The majority of the "black" respondents preferred pinto beans and black-eyed peas, while the "white" respondents preferred kidney, white navy, and garbanzo beans. The "other" race category, which was primarily Oriental, preferred red, garbanzos, kidney, and soy bean products.

[3/] The percentages do not add to 100 because first and second choices were added together.

TABLE 4.--Distribution of households by reasons given for not serving beans more often and by age of major cook[1,2/]

Reasons for not serving beans more often	Age of major cook			
	Younger than 35 years	35 to 45 years	45 to 55 years	55 years or older
	Percent	Percent	Percent	Percent
Like other foods better	60	40	43	41
Cause intestinal gas	10	23	32	32
Not in habit of cooking them often	30	21	13	9
Too long to prepare	23	19	11	5

[1/] Includes dry beans, peas, and lentils. [2/] Percentages will add to more than 100 because each percent includes those households which ranked the reasons first or second in order of importance.

TABLE 5.--Distribution of households by types of beans served and by ethnic group[1,2/]

Types of beans served	All households	Ethnic group		
		White	Black	Other[3/]
	Percent	Percent	Percent	Percent
Kidney	35	39	17	27
Garbanzo (chick peas)	27	28	11	36
White navy	26	30	17	0
Red	23	22	22	36
Split pea	21	25	6	18
Pinto	20	12	67	18
Lima	19	19	22	18
Lentil	17	13	0	9
Black-eyed peas	10	5	44	0
Dry whole green pea	3	2	0	18
Other[4/]	5	4	0	27

[1/] Includes dry beans, peas, and lentils. [2/] Percentages will add to more than 100 because each percent includes those households which ranked the type of bean first or second in order of importance. [3/] Sixty-four percent were Oriental households.
[4/] Includes soy beans, pink beans, cranberries, and dry whole yellow beans.

The most popular form of beans served were canned beans, followed by regular dry beans and canned bean soup (table 6). Only a small proportion of the respondents indicated that they served other forms of beans. By age of cook, a larger proportion of the older cooks used regular dry beans more often than the younger cooks, while a larger proportion of the younger cooks used ready-prepared bean products, such as frozen bean dinners. Again, however, significant tests could not be computed because the first and second choices were combined. There was also some indication that the higher the income level the more canned beans were used in the household. This difference by income has been found in other studies.

The favorite bean dish served was chili, followed by bean soup and pork and beans (table 7). Chili and pork and beans were the favorite dishes in the larger size households, while bean soup and chili appeared to be the favorite of the smaller size households.

Slightly more than half of the respondents indicated that they ordered beans in restaurants either often or occasionally (table 8). There was an indication that, regardless of household size, persons who liked beans ate them both at home and at restaurants.

Almost 90 percent of the respondents indicated that there had been no change in the quantity of beans consumed in the household during the 6-month period of the survey as compared with the previous 6 months. The few changes that were made were primarily related to either restricted diets or to the increase or decrease of family size.

About one-fourth of the respondents indicated that they thought that beans could be improved (table 9). The improvements mentioned were primarily in the areas of reducing both flatulence and length of preparation time. Respondents who served the largest quantities of beans were the ones who were most concerned with these problems. It was also these respondents who indicated a desire for better tasting or spicier products. Other suggestions for product development given by the respondents included: 1) the manufacture of a chocolate-covered bean-paste candy and 2) the use of beans as the base in low-cost snack items.

Summary: In this study of households with incomes above the poverty level, the two household characteristics which were significantly related to the total consumption of beans were: (1) household size and (2) whether the major cook was used to eating beans as a child. A significant

TABLE 6.--Distribution of households by forms of beans served and by age of major cook[1,2/]

Forms of beans served	All households	Age of major cook	
		Younger than 45 years	45 Years or older
	Percent	Percent	Percent
Canned (not soup)	75	63	71
Regular, dry	58	49	67
Canned soup	46	46	45
Other[3/]	17	18	9

[1/] Includes dry beans, peas, and lentils. [2/] Percentages will add to more than 100 because each percent includes those households which ranked the forms of beans first or second in order of importance. [3/] Includes ready-prepared (frozen and unfrozen), dry quick-cooking, and instant dried soups.

TABLE 7.--Distribution of households by bean dishes served most frequently[1,2/]

Bean dishes served	All households
	Percent
Chili	44
Bean soup	35
Pork and beans	34
Bean salad	22
Baked beans	21

[1/] Includes dry beans, peas, and lentils. [2/] Percentages will add to more than 100 because each percent includes those households which ranked the bean dish first or second in order of importance.

TABLE 8.--Distribution of households by size eating beans at home and in restaurants in 6 months' period

Order beans in restaurants	All households	Beans served in 6 months			
		Fewer than 10 times in		10 or more times in	
		Household size		Household size	
		One or two	Three or more	One or two	Three or more
	Percent	Percent	Percent	Percent	Percent
Yes	54	52	34	73	62
No	46	48	66	27	38

1/ Includes dry beans, peas, and lentils.

TABLE 9.--Distribution of households commenting on improvement of beans and quantity of beans served in 6 months[1/]

Comments on improvement of beans	All households	Beans served in 6 months	
		Less than 10 pounds	10 or more pounds
	Percent	Percent	Percent
A. Could beans be improved:			
Yes	27	16	38
No	16	17	15
No response or don't know	57	67	47
B. If yes, how:			
Reduce flatulence	11	9	13
Reduce preparation time	10	4	10
Better tasting and spicier products	3	0	8
Other[2/]	3	3	7

[1/] Includes dry beans, peas, and lentils. [2/] Includes better recipes, cleaner products, better digestibility.

number of the younger cooks as compared with the older cooks were not used to eating beans as children or had disliked them. The younger cooks were also more concerned about the length of the preparation time whereas the older cooks were more concerned about flatulence. Further, a higher proportion of the younger cooks as compared with the older cooks indicated that (1) they liked other foods better and (2) they were not in the habit of cooking beans often.

Considering that the major reason given for not serving beans more often was that other foods were liked better, one way of increasing bean consumption might be the development of new bean products. Spicy, quick-cooking or ready-prepared bean dishes with built-in appeal for the younger age groups, along with an intensive advertising campaign to promote these products, might help increase bean sales.

VARIATION IN PROTEIN CONTENT AND ITS RELATION TO OTHER CHARACTERS IN BEANS (*PHASEOLUS VULGARIS* L.)

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An increase in the protein content of dry beans would be desirable, especially if the increase could be achieved without concomitant reductions in yield. Little has been published on the variation in protein content or its relation to other characters in beans. Information of this type is needed to provide a sound basis of breeding for protein content in the crop. This paper reports the crude protein content of bean lines grown in nurseries in New York and the relation of protein to several other characters. The influence of environment on protein content is also briefly examined.

In a preliminary study, residual seed from a yield trial was analyzed to obtain information on the importance of year and location effects on protein content. The yield trial contained eight varieties, grown at Ithaca and Aurora, N.Y., for 3 years. A randomized complete block design with four replications was used in each planting. Protein determinations were by the standard Kjeldahl method (protein = 6.25 X N).

Concurrently with the preliminary study, over 1,000 bean lines from the Northeastern Regional Plant Introduction Station were grown in a nursery near Aurora, N.Y., in 1967. Protein and oil determinations were made on seed samples from 343 random lines from one replication of the trial; maturity (as measured by days from planting to harvest), common bean mosaic virus (BVI) reaction, seed weight, and yield were measured on two replications. Protein determinations again were made by the Kjeldahl method. Oil content was determined by wide-line nuclear magnetic resonance (NMR) analysis (2) and checked by ether extraction methods. Oil content was determined because it was hoped that oil and protein would be negatively correlated to such a degree that oil content could be used as a selection indicator.

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In the next year, 105 of the 343 lines described above were again evaluated for maturity, seed weight, and yield in two replications. Protein content was determined on one replication. Oil content was not measured the second year.

Ten of the highest protein lines were further evaluated in an eight-replicate yield trial at Ithaca in 1969.

Highly significant year, location and variety effects on protein content were found in the eight-variety yield trial (table 1). Year X location and variety X year interactions also were highly significant. Year and variety effects, as well as variety X location and variety X year interactions, were significant for yield (table 1). A much lower coefficient of variation was obtained for protein than for yield, indicating that considerably less replication is needed for protein determination than for yield. Therefore, in subsequent studies protein determinations were made on only one or two replications per test.

The magnitude of the environmental influence on protein content is given in table 2. Thus the average protein content of the eight varieties ranged from 22.5 percent in year 2, location 1 (Y_2L_1), to 36.2 percent in year 1 location 2 (Y_1L_2). These data, together with the significant variety X year interaction previously noted, demonstrate the importance of increasing seed of all materials in a single environment before analyzing for protein content. The causes of the environmental differences in protein are unclear; however, it was known that the Y_1L_2 test was in a particularly high nitrogen location (90 pounds/acre of nitrogen plowed down, followed by 40 pounds/acre applied in the row at planting; the previous crop on the field was alfalfa, which might be expected to release additional nitrogen during the summer). There was an obvious inverse relationship between protein percentage and yield among these six environments. The decrease in yield was proportionally greater than the increase in protein content, so that the highest production of pounds of protein per acre was at the lowest protein percentage (table 2).

The range of protein contents among the eight varieties evaluated in the above yield trials was only 3 percent, so a diverse array of plant introductions was examined. Much greater genotypic variability was found. Protein content of the 343 lines grown and analyzed in 1967 ranged from 19 to 31 percent, with a mean of 24.6 percent (fig. 1). A

TABLE 1.--Mean squares from the analysis of variance on two characters in 8 bean varieties

Source[1/]	df	Protein[2/]	Yield[2/]
Y	2	1,990.42**	13,494,077**
L	1	108.65**	1,129,021
YL	2	122.45**	672,163
E_a	18	3.37	256,768
V	7	35.90**	861,235**
VL	7	1.45	216,033*
VY	14	5.12**	421,407**
VLY	14	1.93	126,925
E_b	126	1.94	96,194
Coefficient of variation (percent)		5.0	17.6

1/ Y denotes year; L denotes location; and V denotes variety.
2/ *, ** Significant at 5 and 1 percent levels, respectively.

TABLE 2.--Average protein content, bean yield, and protein yield of 8 bean varieties grown in 6 environments

Environment[1/]	Protein content	Yield	Protein yield
	Percent	Pounds/acre	Pounds/acre
Y_2L_1	22.5	2,480	560
Y_2L_2	24.0	2,090	500
Y_3L_1	26.8	1,620	430
Y_3L_2	25.6	1,580	400
Y_1L_1	31.9	1,430	460
Y_1L_2	36.2	1,400	510

[1/] Y denotes year; L denotes location.

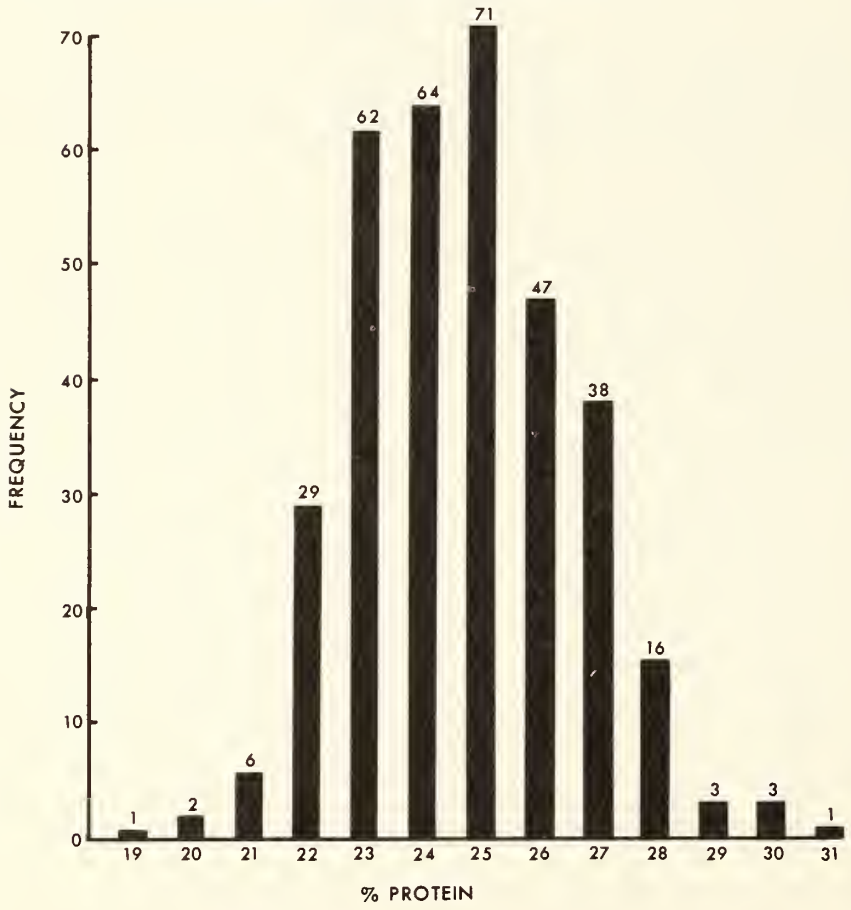

Figure 1.--Frequency distribution for protein content of 343 bean lines grown in New York in 1967.

few lines of three other Phaseolus species were also analyzed. The mean of each species (P. coccineus, P. lunatus, and P. angularis) was lower than the P. vulgaris mean (table 3).

TABLE 3.--Average protein content of four Phaseolus species grown in 1967

Species	Entries	Protein content
	Number	Percent
P. vulgaris	343	24.6
P. coccineus	7	19.7
P. lunatus	4	20.4
P. angularis	1	20.0

Correlation coefficients were calculated between protein and other characters in the 343 lines grown in 1967 and in the 105 lines grown in both 1967 and 1968.

The significant positive correlation between protein and days to harvest (table 4) indicates that late-maturing

TABLE 4.--Correlation coefficients between several characters in beans

	Protein content[1/]		Oil content[1/]
	1967	1967-68	1967
	341 df	103 df	341 df
Days to harvest	0.21**	0.26**	-0.09
Yield	-.09	-.06	.11*
Seed weight	-.23**	-.36**	.00
Oil	-.22**	--	--

[1/] *, ** Significant at 1 and 5 percent levels, respectively.

lines tend to be higher in protein. Yield and protein content were not significantly correlated. Consequently it should be possible to combine high levels of yield and protein. Small-seeded lines tended to be higher in protein than large-seeded lines, as shown by the negative correlations between protein and seed weight (table 4). Protein and oil content were also negatively correlated. Oil content was not correlated with days to harvest or seed weight.

TABLE 5.--Contingency tables for protein versus collection site, protein versus growth type, and protein versus BVI score in beans

Protein level	Protein versus collection site (a)		Protein versus growth type (b)		Protein versus BVI score (c)		
	Central America[1/]	Elsewhere[2/]	Bush	Pole	0-1 (tolerant)	2-3 (intermediate)	4-5 (susceptible)
High (27.0-31.0)	11	23	11	23	11	17	6
Medium (22.5-26.9)	29	246	100	175	103	144	28
Low (19.2-22.4)	4	30	19	15	9	19	6
	$x^2 = 12.91$[3/]		$x^2 = 5.39^{ns}$		$x^2 = 0.70^{ns}$		

[1/] Costa Rica, El Salvador, Guatamala, Honduras, Mexico, and Nicaragua. [2/] Collected from countries in South America, North America, Europe, Africa, and Asia. [3/] Significantly exceeds tabular x^2 value at 1 percent level.

A small positive correlation was found between yield and oil content. In the 2-year analyses, protein again was positively correlated with days to harvest, uncorrelated with yield, and negatively correlated with seed weight.

The negative correlations between protein and seed weight might hinder development of high protein lines of large seed weight; however, these correlations are relatively small and should cause little difficulty. The negative correlation between protein and oil is too small to be of appreciable value as a selection indicator for high protein content. Oil content of all lines was rather low, ranging only from 0.3 to 1.4 percent.

Because Central America is thought to be the center of origin of the common bean and thus might be expected to be the area of greatest diversity (3), the relationship between protein level and collection site was investigated. For this purpose the 343 lines were arbitrarily divided into high, medium, and low protein groups, corresponding to the highest 10 percent, the intermediate 80 percent, and the lowest 10 percent of the lines. The resulting contingency table comparison (table 5, a) indicates that high protein lines were not distributed at random between Central American and other countries. A disproportionately larger share of high protein lines come from Central America (Costa Rica, El Salvador, Guatemala, Honduras, Mexico, and Nicaragua). Central American lines were smaller seeded, averaging 207 mg./seed compared with 365 mg./seed for the rest of the collection. Therefore, the presence of a larger proportion of high protein lines from Central America may be due in part to the negative relationship between seed size and protein content. Further investigations on the interrelationships of origin, seed size, and protein level are needed.

Other contingency table comparisons show that there was no relationship between protein level and growth type (table 5, b), nor between protein level and BVI score (table 5, c).

Characteristics of 10 lines which were consistently high in protein content during 3 consecutive years are given in table 6. All 10 were significantly higher in protein content than the Black Turtle Soup check variety, and eight were higher than the Redkote check. Five of these 10 lines were collected in either Mexico or Guatemala, which suggests that future studies on screening for high protein levels should be concentrated on lines from these countries.

TABLE 6.--Characteristics of 10 high-protein bean lines and 2 check varieties grown in New York

P.I. No. and variety name	Origin	Protein content (3-year mean)	Weight (100 seeds)	BVI score (0 = resistant, 5 = susceptible)	Growth type	Days to harvest
		Percent	Grams			
190073	Guatemala	30.7	15.3	3	Pole	132
165455	Mexico	30.4	22.4	2	Pole	132
226937A	Germany	30.4	35.0	1	Bush	120
203958	Mexico	29.9	17.7	1	Pole	120
109859R	Venezuela	29.9	21.2	1	Pole	135
309786B	Mexico	29.5	22.6	3	Pole	142
229815	USA	29.4	29.0	2	Bush	110
163555	Guatemala	28.7	25.9	3	Pole	125
297077	Poland	28.4	28.4	2	Bush	125
199040RS	Congo	28.3	57.2	3	Bush	110
Redkote	USA	26.5	64.0	3	Bush	110
Black Turtle Soup	USA	25.1	23.1	2	Pole	121
$LSD_{.05}$		2.0	--	--	--	--

Nine of the high protein lines in table 6, plus another (P.I. 163117) which was thought to be high in protein, and the two check varieties were yield tested in 1969 (table 7). Only five of these lines were significantly higher in protein than the Redkote check in 1969. In the 3-year test (table 6), seven of these same nine lines were higher in protein than Redkote. Some of the P.I.'s initially were rather heterogeneous for agronomic characters. During the 3 years these lines were grown in New York, there was some natural selection for earliness because of the relatively short growing season. Because high protein and late maturity were found to be positively correlated (table 4), selection for early maturity may be expected to lead to lower protein levels. Whether this is what has indeed happened is not entirely clear because considerable environmental influence on protein content has been observed. However, the fact that some P.I.'s are heterogeneous for agronomic characters makes the testing of protein levels in different years imperative.

Another type of selection was observed in P. I. 163117. This line was the second highest protein line found during the 1967 screening of 343 lines. In 1968 the line was observed to be segregating for resistance to bacterial blight. Nearly half of the plants grown in 1968 were killed by the disease and consequently produced no seed. The surviving plants were harvested in bulk and designated P.I. 163117 Selection 68-1. In 1969 this selection was the highest yielding variety tested, but was not significantly higher than the check varieties in protein content (table 7). Apparently the high protein content observed in the original seed lot of P.I. 163117 was associated with susceptibility to blight. Thus P.I. 163117 Selection 68-1 does not appear useful as a germ plasm source of high protein content. However, because of its high yield, Selection 68-1 produced more pounds of protein per acre than the check varieties or the other lines (table 7). From results such as these it could be argued that a plant breeder should be more concerned with yield than with protein content. Nevertheless, experience with other crops such as wheat and soybeans has shown that protein levels can be raised without concomitant reductions in yield. Since the correlations between yield and protein in beans were found to be small and nonsignificant (although negative), it should be possible to eventually introduce higher protein levels into high yielding varieties.

Two graduate students at Cornell have worked on problems related to protein content. Ono Leleji is studying

TABLE 7.--Protein content, bean yield and protein yield of ten high protein bean lines and two check varieties in 1969

P.I. No. and variety name	Protein content[1/]	Yield	Protein yield
	Percent	Pounds/acre	Pounds/acre
190073	29.1	760	220
165455	28.1	800	225
226937A	29.7	670	200
109859R	29.5	870	255
309786B	26.9	1680	450
229815	27.3	450	120
163555	28.2	1110	315
297077	26.8	870	235
199040RS	26.4	400	110
163117 Sel. 68-1	26.7	1960	525
Redkote	25.9	910	235
Black Turtle Soup	25.0	1520	380
$LSD_{.05}$	2.0	310	--

[1/] Protein versus yield correlation = -0.32^{ns}.

the inheritance of protein quality and quantity in crosses between high and low protein sources. L. S. Beckham (1) studied the effect of nodulation by Rhizobia phaseoli on beans. Nodulation had no effect on protein content of field-grown seed, but different R. phaseoli strains have been found to influence seedling nitrogen content (1).

Conclusions.--Large year and location effects and variety X year interactions demonstrated the importance of growing materials in a common environment before screening for protein content.

Protein content of 343 bean lines ranged from 19 to 31 percent, with a mean of 24.6 percent. Protein content was positively correlated with late maturity and negatively correlated with seed weight and oil content. Though statistically significant, the correlations were small. Yield and protein content were not significantly correlated. There was no relationship between protein level and growth type, nor between protein level and virus score. The frequency of high protein lines was greater in collections from Central America than elsewhere.

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BEAN PROTEIN IMPROVEMENT WORK BY USDA-- BEAN AND PEA INVESTIGATIONS

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Recent emphasis on present and future world food problems, especially protein deficiency in developing nations, has stimulated a great deal of international interest in the nutritional value of legumes.

In the United States, an increased public awareness of the health benefits and of the economic importance of high-quality proteins in human and animal diets has likewise generated a great deal of interest in legumes. Justification for public research in the area of improving the nutritional value of beans includes such possible benefits as: (1) The improvement of human and animal diets in the United States. (2) The alleviation of dietary protein deficiencies in developing areas. (3) Providing a low-cost protein substitute for meat, milk, and eggs in view of increasing planetary competition for food and space and the rising cost of living. (4) By the realization of goals 1, 2, and 3, generating greater demands for beans in domestic and foreign markets.

The U.S. Department of Agriculture, Agricultural Research Service, Crops Research Division, Vegetables and Ornamentals Research Branch, Bean and Pea Investigations is participating in legume protein improvement work by:

(1) Direct research:
   (a) Beans - M. J. Silbernagel, Prosser, Wash. (about 10 percent)
   (b) Dry Peas and Lentils - V. E. Wilson, Pullman, Wash. (about 10 percent)

(2) Providing Cooperative Agreement funds:
   (a) $32,000, 1967-69 to Washington State University to try to develop rapid screening chemical techniques for methionine and cystine and to conduct certain animal feeding trials with beans as the protein source.
   (b) $32,000, 1969-71 to Michigan State University to continue the search for rapid screening techniques for methionine, cystine, and tryptophane and to identify

genetic materials that can be used in breeding programs to improve protein quantity and quality.

(3) Cooperation with the U.S. Agency for International Development (US/AID): providing short-term consultants for the legume projects in India, Iran, San Salvador, and Brazil.

There are a number of important ways in which beans can be improved nutritionally via a breeding program: (1) Improve protein quality by increasing the levels of those essential amino acids, which are presently limiting. (2) Increase total protein content to over 30 percent. (3) Reduce or eliminate toxin content. (4) Improve digestibility including the elimination of flatulence.

Although beans are relatively high in total protein content (about 24 percent), their actual nutritional value as a total source of human (or animal) dietary protein needs is limited to about 8 percent, because of the low levels of the sulfur-containing amino acids, methionine and cystine. Even if the levels of the sulfur-containing amino acids were adequately increased to keep them from being limiting, then tryptophane would be limiting. According to a study sponsored by the Food and Agriculture Organization of the United Nations (Legumes in Human Nutrition, 1964), an ideal protein source (eggs, milk) should have a certain amino acid ration or pattern. Comparison of beans as a protein source with the FAO provisional pattern indicates that beans need about twice the present tryptophane content and three times the present level of the sulfur-containing amino acids, methionine and cystine in order to make all 24 percent of the protein content in beans available as a dietary protein source.

The USDA bean protein improvement work at Prosser over the past 4 years has concentrated in the following areas: (1) Search for high total protein content in commercial and plant introduction materials. (2) Studies of some of the environmental variables that might influence total protein or methionine content or both, such as seed quality, water stress or excess, pesticides, location, nitrogen-phosphorous, and zinc fertilization. (3) Initiation of a hybridization program between lines of different protein content, to study the inheritance of protein content. (4) Comparative studies of the protein content of the major seed components (cotyledons, embryo, and seedcoat) to determine if we could account for protein content differences between varieties or variation within a variety.

Most of the studies described below were carried out by various researchers for purposes other than studying the effects on protein or methionine content. Reference is made in the table headings to the cooperators. These cooperators were kind enough to supply me with seed samples from their experiments, with which to gather some information on protein content. The protein determinations were made on an Udy protein analyzer, and most of the methionine determinations were supplied by Jack Kelly of the Campbell Research Institute, to whom I am most grateful. My appreciation also to John Lawrence of WSU for the amino acid analyzer data and to all the cooperators who supplied seed from their experiments.

Both high- and low-protein lines have been increased and tested for several generations on a single plant basis. A few lines have been found to be relatively stable for both high- and low-protein content, but most vary greatly from year to year. These are obviously segregating in some cases; however, in others, the differences in protein content may be due to differential sensitivity to environmental factors which may influence protein content. Range in total protein content varies from about 16 percent in some selections out of P.I. 164897 to about 30 percent in some selections out of P.I. 186493.

Seed quality was one of the first things examined in a series of studies to identify some of the sources of variations in protein content and to determine the extent of their influence. Poor, shriveled seed has a protein content about 3 percent higher than that of good seed, however, seed size alone is not the responsible factor.

We often found that seed of a given variety grown at different locations varied in protein content. However, latitude and differences in photoperiod do not seem to be the determining factors (table 1). The differences in the amount of variation in protein content between the varieties included in table 1 might suggest differences in sensitivity to external factors, which influence protein content.

Thinking that some differences in protein content between varieties and even within a variety may be genetic, we kept track of single plant selections out of high- and low-protein lines for several generations. Some of the low-protein lines varied as much as 8 or 9 percent between single plant selections from the same seed lot (16 to 25 percent). Table 2 compares three high-protein, single plant selections, grown at two locations. Although the

TABLE 1.--Study of effects of location and variety on protein content of bean seed 1967 (Regional Cooperative Dry Bean Nurseries)

City	State	Seed protein content in variety						
		Pinto R-220	Pinto UI-114	Red Mex. Bigbend	Pinto 166	Red Mex. OR-5	Red Mex. UI-36	Location Average
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
Lubbock	Tex.	24.1	22.6	23.1	22.5	25.0	23.6	23.5
Minn.	Minn.	22.7	22.1	22.3	23.5	24.5	24.0	23.2
Scotts Bluff	Nebr.	21.8	23.7	--	22.3	--	22.3	22.5
Tribune	Kans.	22.7	21.7	22.6	22.5	23.7	21.4	22.4
Ft. Collins	Colo.	21.0	23.6	21.5	21.1	23.6	22.1	22.1
Prosser	Wash.	--	21.9	23.2	21.7	22.3	21.4	22.1
Sydney	Mont.	21.8	22.3	22.1	22.3	22.3	21.7	22.0
Kimberly	Idaho	19.9	22.7	19.1	20.3	21.5	19.9	20.6
Othello	Wash.	--	22.3	18.6	--	20.8	19.9	20.4
Torrington	Wyo.	19.4	20.1	18.9	18.7	22.7	18.5	19.7
Powell	Wyo.	19.0	20.0	18.7	19.6	19.1	16.7	18.8
High-low difference		3.7	3.8	4.6	4.8	5.4	7.3	4.7
Protein average		21.4	22.0	21.0	21.4	22.5	21.0	--

TABLE 2.--Study of effects of location and seed size on percentage protein in whole bean seed; percentage of total weight, percentage of total protein, and percentage protein content of seed components, in three single plant selections

P.I. No.	Location	Seed weight	Seed	Whole seed protein content	Total weight			Total protein			Protein content		
					Seedcoat	Embryo	Cotyl	Seedcoat	Embryo	Cotyl	Seedcoat	Embryo	Cotyl
		Gram	Number/ pound	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
186493-2	Prosser	0.48	909	29.2	6.6	1.1	92.3	2.7	1.8	95.4	11.0	42.6	27.4
	Puerto Rico	.29	1578	24.4	9.2	1.3	89.6	3.4	1.9	94.6	9.4	40.6	27.3
186493-3	Prosser	.47	968	27.8	6.7	1.0	92.3	2.8	1.5	95.5	11.8	43.4	29.1
	Puerto Rico	.28	1578	27.5	9.2	1.4	89.4	3.4	2.3	94.3	10.4	45.4	29.6
186493-4	Prosser	.46	1000	29.1	7.3	1.3	91.4	3.0	1.9	95.0	12.5	46.6	31.4
	Puerto Rico	.26	1764	23.3	9.2	1.6	89.2	3.9	2.7	93.3	10.7	44.0	26.4

Puerto Rican grown seed was considerably smaller, the Prosser grown seed had a higher protein content. Only one line, P.I. 186493-3, produced seed of high-protein content at both locations.

The protein content of the seed components, the percentage of the total weight, and percentage of the total protein contributed by the seedcoat, embryo, and cotyledons were also compared in tables 2 and 3. Although there are quantitative differences in the protein content of the seedcoat and embryo, these differences are too small, in view of the percentage of the total protein contributed by the cotyledons, to account for the large difference between P.I. 186493-3 (27.8 percent) and P.I. 169897 (20.1 percent).

The inconsistencies observed in table 3, in trying to relate the percentage of protein of the whole seed to the protein content of the seedcoat, embryo, and cotyledons and to the percentage of total weight and protein contributed by those components, are typical of the kinds of frustrations usually encountered in trying to account for differences in protein content and the variation observed.

The data shown in table 4 indicate that there is a difference in protein content between the two varieties but that neither the amount of nitrogen fertilizer nor the kind of nitrogen carrier has any effect on bean seed protein content. Likewise no differences due to nitrogen carrier or rate were found in the methionine content (table 5). When nitrogen and phosphorus were varied, again no effect was seen on protein content (table 6).

Another study involved zinc fertilization in combination with phosphorous from 50 to 1,600 pounds per acre. No effects were observed on protein content or methionine content (tables 7 and 8).

In yet another study, the effects of zinc seed treatments, with and without soil zinc, were compared. Again no effects were observed on total protein or methionine content (tables 9 and 10).

Analysis of seed from an experiment set up to determine the irrigation needs of snap beans showed that neither too much water (daily or 1/2 inch) or too little water (2 inches) had any influence on seed protein content (table 11).

TABLE 3.--Study of effects of varietal differences on percent protein in whole bean seed; percent protein content of seed components, percentage of total weight, and percentage of total protein

P.I. No. and variety name	Whole seed protein content	Total weight			Total protein			Protein content		
		Seedcoat	Embryo	Cotyl	Seedcoat	Embryo	Cotyl	Seedcoat	Embryo	Cotyl
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
186493-3	27.8	6.7	1.0	92.3	2.8	1.7	95.5	11.8	45.4	29.1
Apollo	23.5	8.7	1.2	90.1	3.2	2.4	94.2	8.8	47.4	24.4
Soldier	23.4	6.8	1.5	91.7	2.3	2.7	95.0	7.4	40.8	23.1
169897	20.1	8.6	1.2	90.2	3.8	2.1	94.0	9.1	38.2	21.4

TABLE 4.--Study of effects of nitrogen rate and carrier on protein content in seed of two Red Mexican-type field beans (Burke and Nelson, 1968)

Nitrogen rate of application	Protein content in --						
	Red Mex. U.I. 36 fertilized with --				Red Mex. Bigbend fertilized with --		
	$Ca(NO_3)_2$	$(NH_4)_2SO_4$	NH_4NO_3		$CA(NO_3)_2$	$(NH_4)_2SO_4$	NH_4NO_3
Pound/acre	Percent	Percent	Percent		Percent	Percent	Percent
0	20.4	20.0	20.5	Average	18.9	19.5	19.3
40	20.4	20.5	20.2	Average	19.0	19.2	19.3
80	20.4	20.2	20.7	Average	19.1	19.3	19.6
120	20.0	20.5	20.4	Average	20.1	20.2	19.7
160	20.4	20.9	20.6	Average	19.3	20.0	20.4

TABLE 5.--Study of effects of nitrogen carrier and rate on methionine content in two dry bean varieties (Kelly, 1969 bioassay)

Nitrogen carrier	Nitrogen rate of application	Total methionine in --	
		Red Mex. U.I. 36	Red Mex. Bigbend
	Pounds/acre	Mg./g. of bean	Mg./g. of bean
Control	0	2.1	1.9
$Ca(NO_3)2$	80	2.2	2.0
$Ca(NO_3)2$	160	2.1	2.1
$(NH_4)2\ SO_4$	80	2.2	2.2
$(NH_4)2\ SO_4$	160	2.2	2.1
NH_4NO_3	80	2.1	2.0
NH_4NO_3	160	2.2	2.1
	Mean	2.16	2.06

TABLE 6.--Study of effects of nitrogen and phosphorus fertilizer on protein content in snap bean variety, Yakima - Othello, 1969 (Berry)

Nitrogen rate of application	Phosphorus rate	Protein content
Pounds/acre	Pounds/acre	Percent
0	60	26.5
50	60	26.5
100	60	25.2
150	60	25.1
150	0	26.4
150	20	26.2
150	40	25.9
150	60	25.9

TABLE 7.--Study of effects of zinc and phosphorous fertilizer on protein content of Red Mexican beans variety Bigbend (Boawn)

Zinc rate of application	Protein content after fertilization with phosphorous at rates (pounds per acre) of --					
	100	200	400	800	1,600	Average
Pounds/acre	Percent	Percent	Percent	Percent	Percent	Percent
50	21.2	20.9	21.6	21.4	22.2	21.5
100	22.0	21.6	21.8	22.8	20.8	21.8
200	22.0	20.4	21.3	20.3	22.0	21.2
400	20.2	22.4	21.3	21.9	21.5	21.5
800	22.3	23.5	21.9	21.9	20.8	22.1
1,600	21.5	23.2	20.4	20.6	21.7	21.5
Average	21.5	22.0	21.4	21.5	21.5	

TABLE 8.--Study of effects of zinc and phosphorous on methionine content in beans (Kelly)

Zinc rate of application	Available methionine after fertilization with phosphorous at rates (pounds per acre) of --					
	100	200	400	800	1,600	Mean
Pounds/acre	- - - - - - - - - - - - Mg. per gram of bean - - - - - - - - - - - -					
50	0.82	0.83	0.70	0.88	0.80	0.81
100	.72	.83	.72	1.04	.65	.79
200	.80	.92	.86	.84	.89	.85
400	.65	.89	1.04	.92	.87	.85
800	.87	.96	.80	.72	1.15	.88
1,600	.85	1.00	.74	.82	.71	.81
Mean	.78	.88	.81	.87	.84	.83

TABLE 9.--Study of effects of zinc seed treatments and soil amendments on protein content of Red Mexican bean variety Bigbend (Rasmussen and Boawn, 1969)

Replication No.		Protein content after seed treatments[1/] --							
		1	2	3	4	5	6	7	8
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
1		22.0	21.9	21.9	21.1	21.2	21.4	21.9	22.6
2		22.1	21.5	22.5	22.2	21.3	21.4	21.5	21.9
3		21.8	22.8	21.2	22.0	21.1	21.7	21.6	20.7
4		21.6	21.8	20.9	21.6	21.6	22.0	20.5	21.1
	Average	21.8	22.0	21.6	21.7	21.3	21.6	21.3	21.5
1		21.3	21.2	22.0	21.5	22.6	22.6	22.2	19.6
2		22.0	22.0	21.6	22.3	22.6	21.1	21.1	21.1
3		20.5	20.2	21.5	19.9	21.1	20.4	21.2	20.9
4		20.8	21.1	22.4	20.8	21.7	21.0	21.9	22.0

[1/] 1. Captan; 2. Zineb; 3. Zinc sulfate + Captan; 4. Zinc sulfate + Zineb; 5. Zn EDTA Chelate + Captan; 6. Zn EDTA Chelate + Zineb; 7. Zn polyflavonoid + Captan; 8. Zn polyflavonoid + Zineb.

TABLE 10.--Study of effects of zinc seed treatments on methionine content in beans (Kelly)

Seed treatment	I		II		III		IV		$\bar{X}$		Total
	Check	Zinc	Check	Zinc	Check	Zinc	Check	Zinc	Check	Zinc	
	Mg. per gram of bean										
1	0.62	0.58	0.62	0.66	0.99	0.90	0.99	0.88	0.81	0.76	0.78
2	.86	.90	.63	.80	.87	.76	.97	.73	.83	.80	.82
3	.58	.56	.71	.68	.90	.97	.71	.71	.73	.73	.73
4	.67	.69	.53	.49	.83	.78	.89	.94	.73	.73	.73
5	.79	.73	.66	.68	.74	.61	.67	.76	.72	.70	.71
6	.92	.60	.71	.53	.91	.88	.90	.76	.86	.69	.78
7	.83	.83	.66	.50	.86	.86	.89	.98	.81	.79	.80
8	.70	.82	.62	.80	.71	.96	.77	.78	.70	.84	.77
$\bar{X}$	.75	.65	.64	.64	.85	.84	.83	.82	.77	.75	.76

TABLE 11.--Study of effects of water stress or excess on protein content in seed of snap bean variety, Yakima (Middleton)

Year	Protein content after irrigation treatments[1/]				
	Daily	1/2 inch	1 inch	1 1/2 inches	2 inches
	Percent	Percent	Percent	Percent	Percent
1966	25.2	24.7	25.7	--	25.1
1967	--	24.4	24.3	24.1	23.3
1969	--	25.6	25.6	25.8	27.0

[1/] Water replaced by sprinkler after indicated amount of water removed from soil. Soil water holding capacity 1.8 inches per foot of soil.

S. K. Ries, Michigan State University, has shown some spectacular increases in protein content of various crops to be induced by the herbicide Semizine. On the chance that some other agricultural pesticides might possibly influence protein content, seed from an experiment conducted to study the effects of various chemicals (seed and soil treatments) on fusarium root rot of beans, were tested for protein content (table 12). Combinations of soil and seed treatments failed to produce any apparent interactions. No differences could be attributed to any of the chemicals used. However, a slightly higher protein content was obtained in the clean field as compared with that in the root rot infected field. This amount of variation, however, is no greater than the variation between two clean fields, so it is very doubtful that the presence of root rot is an influencing factor.

A great deal of additional background information is needed before we can even begin to understand most of the observations reported here. However, although we may not understand why two varieties differ in protein content, we know that they do. Consequently, we have made a number of crosses between lines of known protein content in an effort to learn something about the inheritance of protein content in beans. Several hybrid families are in the F_2 generation now. However, precise F_2 data are impossible because of the lack of a reliable method of analyzing individual seeds but not destroying them so that they can be grown to the next generation. We will have to obtain estimates of F_2 single seed protein content on the basis of F_3 whole plant increases (families).

An amino acid analysis of some of the breeding lines being used in the inheritance study are listed in table 13. As additional breeding lines particularly high in methionine, cystine, and tryptophane are found, they will be crossed to lines high in total protein. As improved lines are developed, their biological usefulness will have to be ascertained in feeding trials as well as by chemical analysis. Years of extensive and expensive research will be required, but eventually we should be able to develop a bean that is as good a source of dietary protein as meat.

TABLE 12.--Study of effects of clean soil vs. root rot soil and various pesticides as soil and seed treatments on protein content in Buff 11 snap beans

Treatments and pesticides	Rate of application	Protein content of beans in "Clean" soil	Protein content of beans in Root rot soil
		Percent	Percent
Soil treatments:			
Disyston	2 pounds/acre banded	22.5	21.8
Temik	2 pounds/acre banded	22.4	20.3
Check		22.5	20.7
Seed treatments			
Captan/dieldrin (CD)	2.5 ounces per 100 pounds	22.0	20.6
CD + Demosan	6 ounces per 100 pounds	23.1	20.9
CD + Vitavax	4 ounces per 100 pounds	22.7	20.7
CD + Plantvax	8 ounces per 100 pounds	22.6	21.0
CD + Benlate	6 ounces per 100 pounds	22.4	20.9
CD + Demosan + Benlate		23.0	20.5
		22.6	20.8

TABLE 13.--Parent lines used in protein inheritance studies (Lawrence, A A Analyzer)

	P.I. 169897-22-C	P.I. 186493-179	P.I. 136691-177	P.I. 167382-178	P.I. 186493-2	P.I. 186493-3	P.I. 186494-4	P.I. 186493-5
	Mg./100 mg. flour							
Aspartic acid	2.60	2.62	2.87	2.62	3.31	3.43	3.21	3.04
Threonine	.92	.91	1.00	.92	1.02	1.04	1.06	1.07
Serine	1.28	1.42	1.50	1.37	1.56	1.56	1.57	1.60
Glutamic acid	3.16	3.57	3.85	3.13	4.31	4.12	4.31	4.20
Proline	1.32	1.52	1.16	1.25	1.45	1.52	1.66	1.60
Glycine	.88	.87	.97	.99	1.06	1.10	1.04	1.12
Alanine	1.00	1.03	1.07	.92	1.10	1.10	1.11	1.12
Cystine	.17	.16	.20	.16	.24	.26	.23	.21
Valine	1.15	1.22	1.30	1.14	1.49	1.40	1.44	1.48
Methionine	.43	.38	.56	.56	.52	.60	.51	.43
Isoleucine	1.01	1.07	1.21	1.06	1.29	1.29	1.29	1.33
Leucine	1.70	1.88	2.03	1.80	2.22	2.25	2.30	2.21
Tyrosine	.68	.71	.78	.77	.90	.88	.84	.85
Phenylalanine	1.21	1.36	1.48	1.38	1.62	1.65	1.61	1.62
Histidine	.62	.62	.71	.62	.86	.74	.74	.90
Lysine	1.59	1.56	1.67	1.59	2.01	1.74	1.82	2.02
Arginine	1.06	1.26	1.87	1.83	1.96	1.93	1.56	2.16
Total sulfur content (meth. and cys.)	.60	.54	.76	.72	.76	.86	.74	.64
Udy, Prosser percent protein	20.2	26.1	28.2	28.3	30.1	30.5	31.9	33.1

MICROBIOLOGICAL METHODS FOR THE ESTIMATION OF METHIONINE CONTENT OF BEANS

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Because of the generally low level of sulfur-bearing amino acids in legumes, the role of beans is limited in preparing a balanced protein diet. Specific quantitative human dietary requirements for amino acids have not been established and little is known about the utilization of plant proteins by humans. A diet with all or most of the protein being supplied by beans would fall short of even the lowest estimates of dietary requirements for methionine or cystine, or both. The amino acid differences within Phaseolus vulgaris (5,6,7,8) suggest that nutritionally improved cultivars can be developed. In order to utilize efficiently the observed differences, it is essential that the plant breeder has available a rapid and reliable test for the evaluation of large populations. The test should be repeatable but need not be highly precise. The accuracy of the test can be judged only after the materials tested have been evaluated in human feeding trials. We are reporting here several methods which we have employed for the detection of potentially significant differences in methionine levels among bean lines.

The value of bacteriological assays of nutritive value of various materials was discussed by Ford (2,3,4). The methods outlined by Ford using Streptococcus symogenes were modified by Boyne, Price, Rosen, and Stott (1). Further modifications of these assay methods in our laboratory have resulted in tests which can be applied readily to large numbers of small samples of dry beans. All media were prepared without modification. Following are the modifications we have employed.

(1) Six grams of bean seed are ground in a Wiley Mill to pass a 40-mesh screen. A 20-mesh screen is suitable, but the results will generally be lower and comparisons must be made with standard material ground the same way. Single seeds or parts of seeds may be employed for the most simplified available methionine assay described below. Seed which has been treated with insecticide or fungicide must be thoroughly washed, rinsed, and dried before grinding.

(2) For total amino acid determinations, 2.5 grams of bean meal are weighed into a 25- X 200-mm. screw-top culture tube and 40 ml. of 2N HCl is added. The caps are tightened and the samples are autoclaved at 115° C. for 5 hours. The hydrolysates are brought to pH 7.0 with 10N NaOH and are brought to 100-ml. volume. Another 10x dilution is made, 2 ml. of the solution are transferred to 16- X 150-mm. culture tubes, and the sample is ready for assay.

(3) For available (as reported by Ford) amino acid determinations, 2.5 grams of bean meal is weighed into a 100-ml. volumetric flask. Twenty ml. of citrate-cyanide buffer and 2 ml. of 4 percent (w/v) crude papain are added. Samples are incubated at 56° C. for 3 hours with continuous shaking. Digests are brought to 100-ml. volume with water, then diluted 10x with water. Two ml. of this solution is transferred to a 16- X 150-mm. culture tube and the sample is ready for assay.

(4) The rapid available amino acid assay we have employed widely does not involve any predigestion of the sample, but relies entirely on the proteolytic action of S. zymogenes. In order to maintain a high level of proteolysis, it is necessary to return to the original culture of the organism. Daily transfers in the prescribed media result in a loss of vigor. About 10 mg. of bean meal (weight recorded accurately) is placed in 16- X 150-mm. culture tubes and is ready for assay. For a rough estimate the sample may be measured with a calibrated scoop which delivers approximately 10 mg.

(5) The assay procedure is as follows: Six ml. (eight for the rapid assay) of water and 3 ml. of methionine-free assay medium are added to each tube. The tubes are covered with plastic caps drilled with 1-mm. holes. The tube racks are covered with aluminum foil and autoclaved for 20 minutes at 100° C. Inoculum, prepared and maintained according to the procedures outlined by Boyne, Price, Rosen, and Stott (1), is drawn into a sterile 2-cc. syringe fitted with a 1-1/2-inch 20-gauge hypodermic needle. The aluminum foil is temporarily lifted and one drop of inoculum is added to each tube. One-half ml. of 1 percent papain may be added here to aid digestion. This yields about two-thirds of the total methionine. Control tubes are left uninoculated. These serve as standards to correct for turbidity from the bean cotyledons and color from the seedcoats. The foil lid is replaced and the racks are incubated 24 hours at 37° C. The 24-hour incubation was adopted after the establishment of a growth curve which indicated that maximum bacterial

growth occurred 23 to 25 hours after inoculation, followed by a slight growth suppression and then a leveling off (fig. 1). The cultures are killed by steaming for 10 minutes

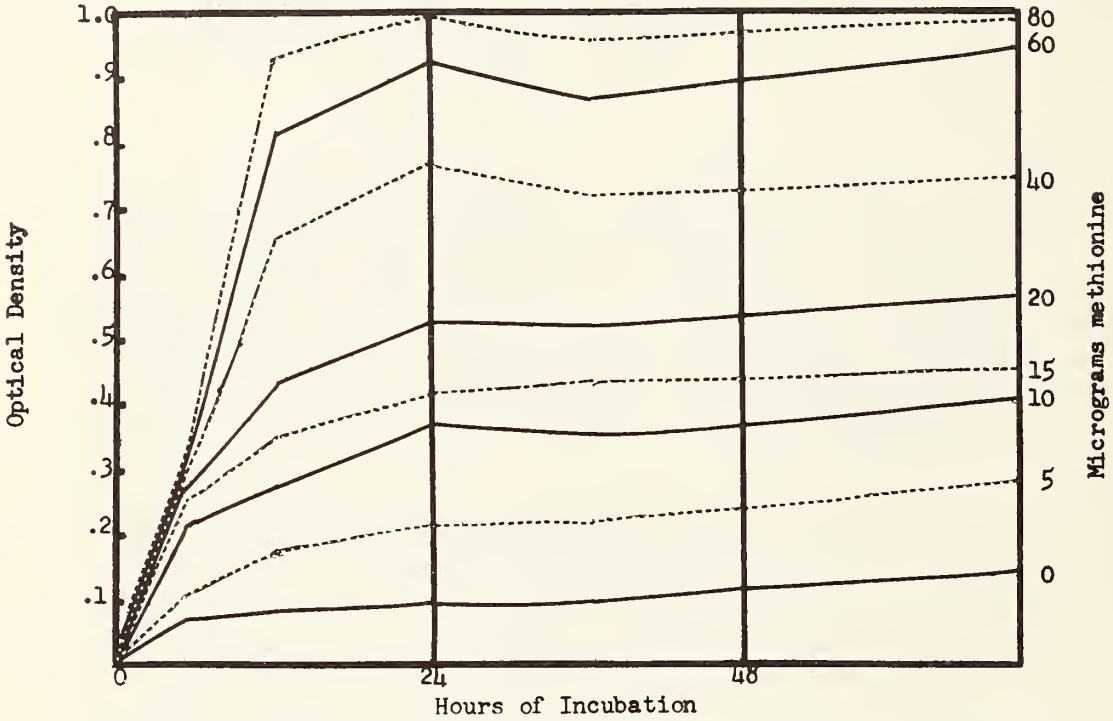

Figure 1.--Growth rate of Streptococcus zymogenes at 8 levels of methionine (micrograms per culture).

in the autoclave, stirred with a vortex mixer, and the turbidity is read within about 5 minutes (to permit seed-coats and other large undigested particles to settle) on a colorimeter set at a wavelength of 580 mμ. The tubes may be read directly if they have been previosuly optically matched or a flow-through attachment may be employed. Tubes containing 0, 5, 10, 15, and 20 micrograms of pure methionine are treated the same as the samples and a standard curve is produced. All samples and standards are run in duplicate. They are rejected and rerun if the two readings are not within the normal range of variation for the assay (3-percent transmittance for total methionine). A single lot of Sanilac beans has been adopted as a standard. Samples of this standard are included in each assay run as an indicator of any factors which may differ among runs.

Table 1 summarizes an experiment conducted to test the reliability of the total methionine hydrolysis and assay. The result on the 1.25-gram sample with no added methionine

TABLE 1.--Results of a reliability test on the total methionine microbiological assay of Sanilac beans

Beans digested	Methionine added	Methionine in aliquot		Methionine per gram of bean	
		Detected	Expected	Detected	Expected
Grams	Milligram	Microgram	Microgram	Milligram	Milligram
1.25	0	6.13	(6.13)	2.45	(2.45)
2.50	0	11.50	(12.26)	2.30	(2.45)
3.75	0	16.72	(18.39)	2.24	(2.45)
1.25	1 (0.8 mg./gram bean)	8.11	(8.13)	3.24	(3.25)
2.50	1 (0.4 mg./gram bean)	13.68	(13.50)	2.74	(2.70)
3.75	1 (0.27 mg./gram bean)	18.81	(18.72)	2.51	(2.51)

was selected as the correct assay because that is the standardized weight employed in the assay to bring the readings into the optimum range. The expected levels were calculated on the assumption that all added methionine would be detected and that increasing the amount of bean would proportionally increase the amount of methionine detected. The agreement between the expected and detected levels indicates that the assay is reliable over a wide range of sample size and methionine level and that losses due to oxidation are not significant.

Table 2 summarizes a sampling experiment which illustrates the precision of the assay procedure for available methionine as determined on papain-hydrolyzed samples. The numbers in parentheses are results expressed as a percentage of the Sanilac standard for the corresponding assay run. Runs I and II were made with a different inoculum batch than III, IV, and V. The apparent differences are minimized by expressing the results as percentages of the standard. We have adopted this procedure for all our bean analyses, making comparison of different tests (e.g., total sulfur vs. total methionine) more meaningful. The low sampling error might indicate that sample duplication is unnecessary but we continue to run duplicates as the surest means of detecting contaminants or experimental error. In large tests we have found this worthwhile because human error is unavoidable (e.g., missing a tube with inoculum).

The statistical evaluation of 506 rapid assays of 217 P. vulgaris single plant selections is presented in table 3. The bean lines were grown in 1969 and were selected for planting on the basis of their 1968 performance (at least 133 percent of the Sanilac standard for available methionine).

These results are similar to other series of samples with respect to coefficient of variability and the difference required for statistical significance from the Sanilac standard. The test is readily capable of detecting medium to large differences in levels of methionine available to the test organism.

The correlation coefficient between the rapid method and the papain-digestion method for available methionine was 0.61 for 27 samples (significant at 1 percent level). The correlation coefficients between the total methionine assay and the papain digest and rapid methods were 0.50 ($n = 27$) and 0.51 ($n = 300$), respectively.

TABLE 2.--Sampling experiment to determine the precision of the available methionine bioassay

Identity	Hydrolysate in[1]-- Run I	Run II	Run III	Run IV	Run V	Mean
	-Mg. methionine per gram of bean-					
Sanilac standard	1.63, 1.55 (100)	1.68, 1.68 (100)	2.10, 2.01 (100)	2.05, 2.01 (100)	1.91, 2.01 (100)	1.85, 1.85 (100)
Vigna sinensis, USA	1.72, 1.82 (111)	1.59, 1.50 (92)	2.05, 2.01 (99)	2.10, 2.01 (101)	1.96, 2.05 (102)	1.88, 1.88 (102)
P. vulgaris, Haiti	0.81, 0.81 (51)	1.29, 1.05 (70)	1.06, 1.10 (53)	1.18, 1.10 (56)	1.38, 1.22 (66)	1.14, 1.06 (59)
P. vulgaris, Haiti	0.97, 0.93 (60)	1.21, 1.06 (68)	1.35, 1.35 (66)	1.35, 1.30 (65)	1.18, 1.18 (60)	1.21, 1.16 (64)
V. sinensis, Haiti	1.72, 1.63 (105)	1.68, 2.10 (113)	2.05, 2.25 (105)	1.91, 2.01 (97)	2.20, 2.15 (111)	1.91, 2.03 (106)
V. sinensis, Haiti	2.20, 2.20 (138)	2.10, 2.05 (124)	2.45, 2.35 (117)	2.29, 2.35 (114)	2.35, 2.40 (121)	2.28, 2.27 (123)
Dolichos lablab, Haiti	0.48, 0.40 (28)	0.33, 0.33 (20)	0.78, 0.71 (36)	0.67, 0.71 (34)	0.75, 0.75 (38)	0.60, 0.58 (32)
Mean	1.35 (85)	1.40 (83)	1.69 (82)	1.65 (81)	1.68 (86)	1.55 (84)

Analysis of Variance

Source	d.f.	S.S.	M.S.[2]
Reps. (runs)	4	1.49	0.37**
Variety	6	21.61	3.60**
Expt. error (R X V)	24	0.45	< 0.02
Sampling error	35	0.29	< 0.01
Total	69	23.84	--

[1] Numbers in parenthesis are results expressed as a percentage of Sanilac standard. [2] ** Statistically significant at the 1 percent level.

TABLE 3.--Analysis of variance of duplicate, triplicate, and quadruplicate determinations of available methionine using the rapid method without predigestion

	Degrees of freedom	Sums of squares	Mean square	F[1/]
Line	216	531,835	2462	5.9**
Error	289	120,583	417	--
Total	505	652,418	--	--

Grand mean = 134 percent of Sanilac standard
Coefficient of variability = 15.2 percent
L.S.D. 0.05 = 37.4 percent; L.S.D. 0.01 = 49.1 percent

[1/] ** Statistically significant at the percent level.

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INACTIVATION OF BEAN ENZYMES BY CONTROL OF pH TO PRODUCE HIGHLY NUTRITIOUS FOOD PRODUCTS

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Mature legume seeds other than soybean are commonly cooked whole. They may be consumed in that form or made into pastes, purees, soups, etc. The cell walls of the cooked moist products are quite resistant to breakage, and the cells tend to separate quite easily (fig. 1). The

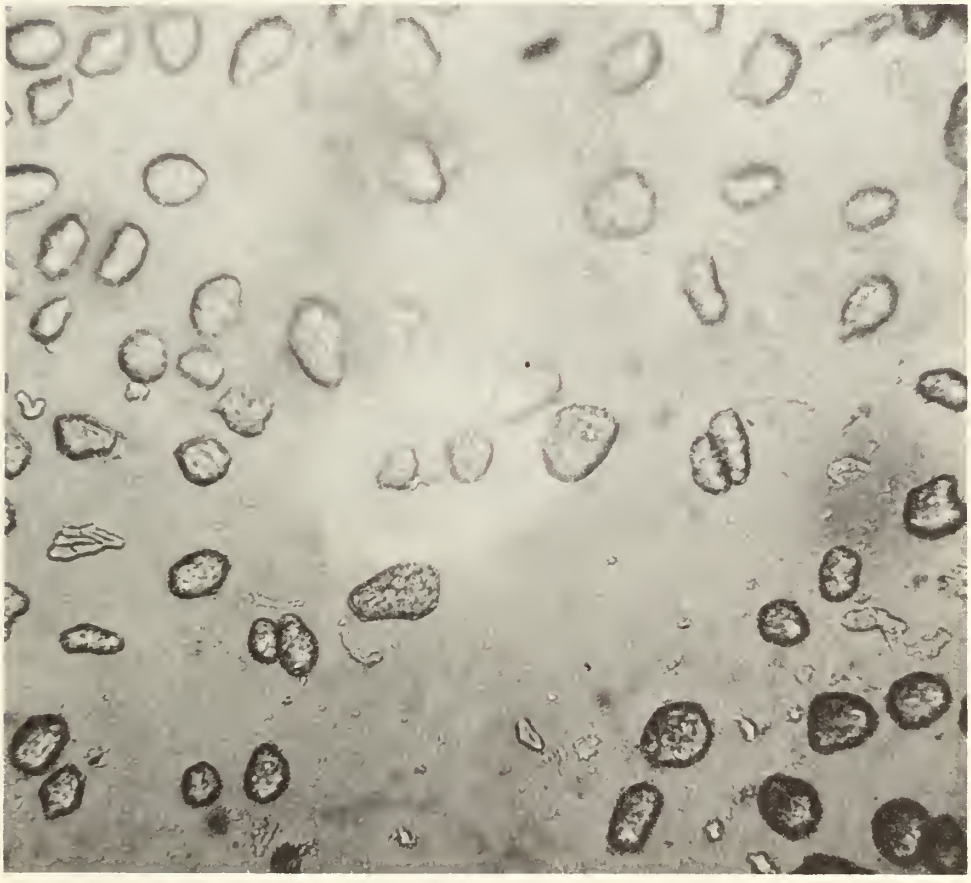

Figure 1.--Photomicrograph of whole bean cooked and blended.

integrity of the cell walls is a factor in the characteristic texture of many bean products. It may also impair their digestibility.

In our laboratory we have repeatedly observed that grinding dry, raw beans or blending raw beans with water to form a slurry causes the breakage of a high proportion of the cell walls (fig. 2). Under those conditions the raw

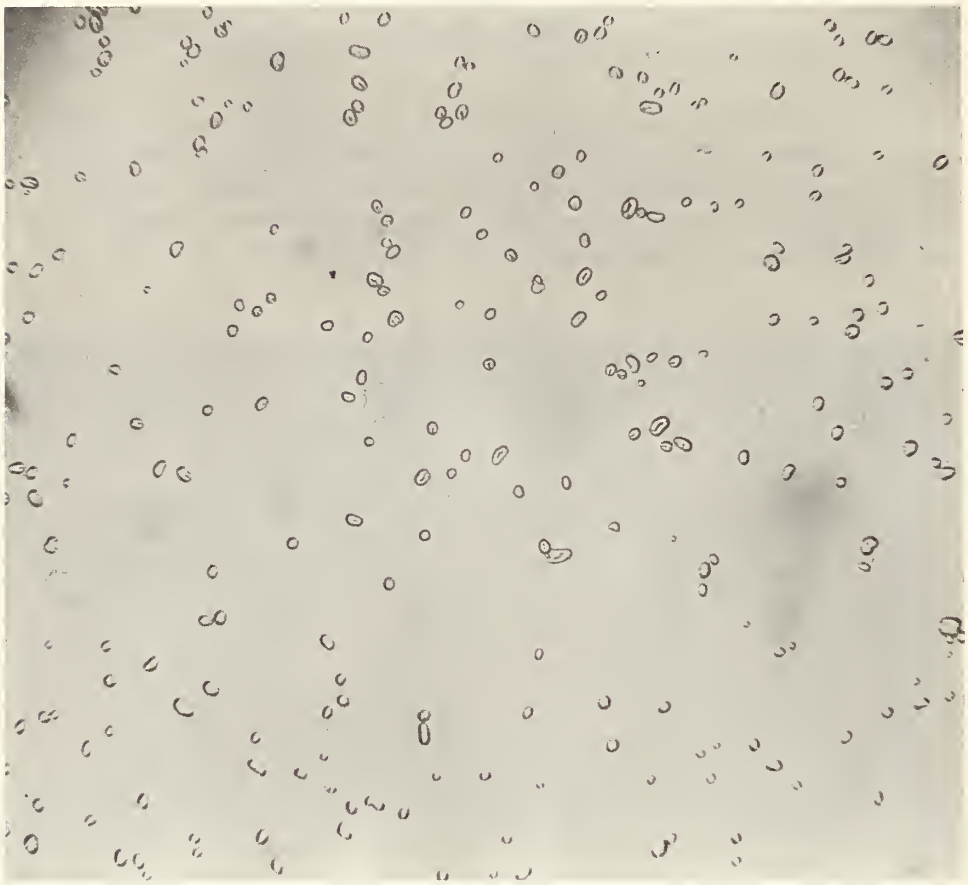

Figure 2.--Photomicrograph of whole bean blended raw.

seeds very rapidly develop undesirable odors and flavors which persist even after cooking. A very similar off-flavor problem exists in the manufacture of soybean milk. The classical oriental method for soymilk production consists of soaking the soybean in cold water for several hours, grinding with added water in a stone mill, filtering to remove insoluble residue, and cooking for about 1 hour. It has been suggested that the lack of popularity of soy beverage or soymilk is due to its characteristic flavor.

The presence of lipoxidase in a number of legumes has been reported. Pea lipoxidase has been implicated in the formation of off odors in unblanched frozen peas. Since lipoxidases catalyze the formation from unsaturated fatty acids or triglycerides of nonvolatile hydroperoxides which in turn decompose to aldehydic compounds associated with rancid painty odors, methods for controlling lipoxidase activity are of interest. A method of producing soybean milk free of rancid off-flavor by use of a high-temperature, rapid-hydration grinding process was proposed. This was supposed to inactivate the lipoxidase without rendering the proteins unextractable with water.

The effects of hydrogen ion concentration on lipoxidase activities have been well investigated, and the pH activity curves for many legumes have been published. We decided to utilize this pH effect to prepare food products free of lipoxidase-induced off-odors and flavors. This was done by adjusting the pH during the grinding and fractionation of raw legume seeds. The products which were prepared by this general method were tested to determine the conditions which will optimize their nutritional quality.

As can be seen in table 1, preliminary determinations

TABLE 1.--Effects of acidification with concentrated HCl during blending of California small white beans

pH	Off-flavor	Nitrogen extracted
		Percent
6.50	Yes	40.4
4.60	Yes	21.7
3.90	Yes	23.9
3.26	No	26.6
2.93	No	33.5
2.40	No	57.5
2.00	No	62.4
1.74	No	64.3
1.60	No	63.4
1.50	No	61.2

by a small untrained panel of judges indicated that the oxidizing of off-flavor of raw ground California small white beans can be controlled by acidifying the blended material to pH 3.85 and below. Below pH 3.85 no detectable off-flavor was produced. At this pH, protein extraction is severely depressed because of the fact that most of the

legume proteins have an isoelectric point around pH 4.0 to 4.5. We found that maximum protein extraction can be achieved when the pH of the slurry is about 2.0. In table 2

TABLE 2.--Effects of acidification with concentrated HCl during blending of soybeans

pH	Off-flavor	Nitrogen extracted
		Percent
6.70	Yes	54.0
5.05	Yes	7.7
4.75	Yes	7.5
4.30	Yes	5.7
3.85	Yes	7.5
3.50	No	11.6
3.02	No	48.0
2.82	No	67.8
2.46	No	77.7
2.14	No	81.6
1.01	No	78.0
0.04	No	47.1

similar results are shown for soybeans. The results in these two tables were obtained using concentrated HCl as the acidifying agent. Similar results were obtained with concentrated H_3PO_4. Some organic acids were tested to determine their capability in lowering the pH. Large proportions of glacial acetic acid lowers the pH to control off-flavor development but, as expected, this acid was too weak for preparation of high protein extracts. Lactic acid and citric acid could be used to achieve the pH levels required for both effects, but the odor of such a high proportion of lactic acid interferred with the appraisal of flavor.

Comparable results can be obtained by grinding the dry legumes in a Wiley mill (screen size 20 mesh) and blending with acidified water. At the moisture level of the legumes tested (about 10 percent for beans and about 6 percent for soybean), no off-flavor could be detected in the ground material or in the acidified blend after storage at room temperature for up to 3 days. No tests were conducted to determine the length of storage of the ground material without oxidative deterioration.

Table 3 summarizes the results of a taste testing panel of 40 untrained judges. The products submitted for

TABLE 3.--Results of sensory preference tests among samples of California small white beans

Comparison[1/]	Sample preferred	Preference	Significance[2/]
		Percent	
d vs. b	None	50	N.S.
b vs. c	c	67	*
d vs. c	c	70	*
a vs. c	c	75	**

[1/] The four samples are: (a) Dry beans blended with water, cooked for 1 hour; (b) dry beans blended with acidified water to give a slurry at pH 3.5, cooked for 1 hour, and neutralized with NaOH; (c) dry beans blended with acidified water to give a slurry at pH of about 2.0, cooked for 1 hour, and neutralized with NaOH; (d) whole beans soaked overnight, cooked for 1 hour, and blended. All samples were adjusted to contain about 0.5 percent NaCl. [2/] N.S. = not significant; * - $P < .05$; ** - $P < .01$; n = 40.

testing were: (A) dry beans blended with water and cooked for 1 hour; (B) dry beans blended with acidified water to give a slurry at pH 3.5, cooked for 1 hour, and neutralized with NaOH; (C) dry beans blended with acidified water to give a slurry at about pH 2.0, cooked for 1 hour, and neutralized with NaOH; (D) whole beans, soaked overnight, cooked for 1 hour, and blended. All samples were adjusted to contain about 0.5 percent NaCl. The data indicates that treatment (c) was significantly preferred over the other three tested, and that there was no significant preference between treatments (b) and (d). It seems from those results that samples extracted at pH 2.0 had a more desirable flavor than those prepared by the other treatments. This suggests that this treatment effectively inhibited the oxidative off-flavor that develops in raw samples blended in water alone.

In figure 3 we can see the results of gas chromatographic analysis of the headspace of four bean samples. The bean samples were prepared in the same manner as those for the taste panel. Five major peaks are identified tentatively as: (1) methane, ethane, or a mixture of the two; (2) propane, butane, or a mixture of the two; (3) pentane, acetaldehyde, or a mixture of the two; (4) pentanal; (5) hexanal. In figure 4 we see similar results for three soybean samples. As can be seen from the two figures, only the water slurries (A) of both the beans and the soybeans had peaks corresponding

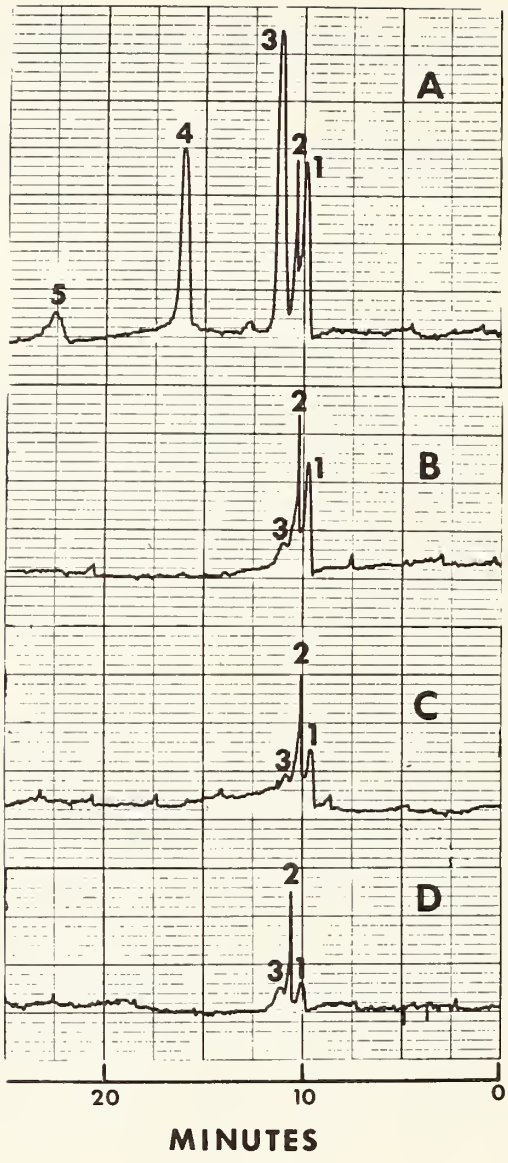

Figure 3.--Gas chromatographic analysis of the volatiles in the headspace of California small white bean samples: (A) Dry beans blended with water, cooked for 1 hour; (B) dry beans blended with acidified water to pH 3.6, cooked for 1 hour, and neutralized; (C) dry beans prepared as in (B) except that the pH was 2.4; (D) whole beans soaked overnight, cooked for 1 hour, and blended. Tentative identification of peaks: (1) methane, ethane, or mixture of the two; (2) propane, butane, or mixture of the two; (3) pentane, acetaldehyde, or mixture of the two; (4) pentanal; (5) hexanal.

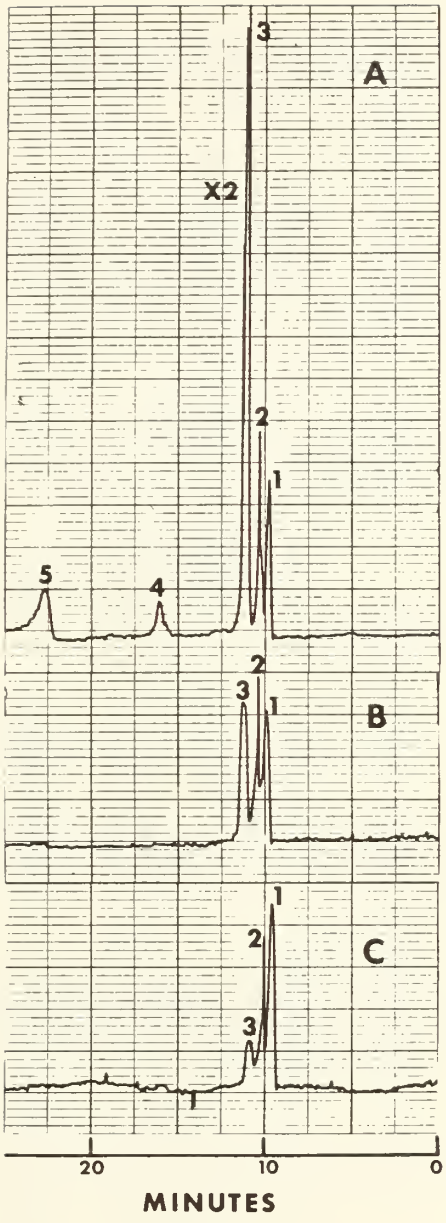

Figure 4.--Gas chromatographic analysis of the volatiles in the headspace of soybean samples: (A) Dry beans blended with water, cooked for 1 hour; (B) dry beans blended with acidified water to pH 3.7, cooked for 1 hour, and neutralized; (C) dry beans prepared as in (B) except that the pH was 2.4. Tentative identification of peaks is the same as in figure 3.

to pentanal and hexanal; also the peak corresponding to acetaldehyde (3) is much larger in those two samples. These results are in agreement with the fact that aldehydes are known to be indicators for the rancid and painty odor and flavor in oxidative deterioration of fats.

As can be seen from tables 1 and 2, more N is extracted from dry beans and soybeans by acidified extraction than by water extraction. A comparison of the soybean material extracted by blending with water and by blending with water acidified to give a slurry of pH 2.2 is shown in table 4.

TABLE 4.--Comparison of dry soybean extraction with water and with acidified water (slurry pH 2.2)[1/]

Components	Extracted with water	Extracted with acid
	Percent	Percent
Protein (N X 6.25)	51.0	80.5
Fat	4.7	51.2
Sugar	79.0	82.0

[1/] The "milk" was prepared by centrifuging the slurry.

As can be seen, much more protein is extracted under those conditions as well as much more fat. Similar results are obtained for beans.

From the appearance of those products, it would seem reasonable to assume that increased accessibility of substrate due to cell breakage will increase the rate of starch digestibility.

In table 5 we can see the results of *in vitro* digestibility experiment with beans prepared in three different ways. As can be seen, the uncooked starch is not being digested very well by α-amylase whether blended in acid or in water. From table 6 it is evident that there is a marked increase in the digestibility of the acid-blended raw starch when the amylolitic digestion is coupled with proteolitic digestion. The digestion in this experiment was with pepsin, followed by digestion with pancreatin which contains trypsin and chymotrypsin in addition to α-amylase.

It seems that in the cooked whole samples, digestion with pepsin and pancreatin was more complete and more rapid than with amylase alone. In one-half hour more than three

TABLE 5.--In vitro digestion of bean starch by pancreatic α-amylase

Material	Starch converted to maltose			
	No enzyme	1-Minute digestion	30-Minute digestion	60-Minute digestion
	Percent	Percent	Percent	Percent
Raw beans:				
Soaked whole then blended	1.64	5.92	5.92	5.92
Blended at pH 3.5	1.32	4.61	6.58	8.88
Blended at pH 2.0	1.64	5.59	7.57	8.22
Cooked beans:				
Soaked whole, cooked, and blended	0.0	6.58	17.11	39.80
Blended at pH 3.5 and cooked	3.95	48.36	62.83	66.78
Blended at pH 2.0 and cooked	23.36	78.29	90.79	95.39
Standard:				
1 percent soluble starch-cooked	0.0	75.99	84.54	90.13

TABLE 6.--In vitro digestion of bean starch by pancreatin following peptic digestion

Material	Starch converted to maltose			
	No enzyme	1-Minute digestion	30-Minute digestion	60-Minute digestion
	Percent	Percent	Percent	Percent
Raw beans:				
Soaked whole then blended	0.0	1.97	4.28	6.58
Blended at pH 3.5	1.64	3.95	11.51	21.05
Blended at pH 2.0	.99	5.26	10.53	19.10
Cooked beans:				
Soaked whole, cooked and blended	0.0	3.62	55.59	59.54
Blended at pH 3.5 and cooked	3.29	53.95	66.45	68.75
Blended at pH 2.0 and cooked	31.25	86.51	98.03	99.67
Standard:				
1 Percent soluble starch-cooked	0.0	76.20	92.11	96.16

times the amount of starch is hydrolized using the combination enzyme treatment as compared with using α-amylase alone. It seems that the major advantage of raw blending and disintegrating the cells, especially at pH 3.5, is in the increase in the rate of hydrolysis rather than in the extent of hydrolysis. This might be quite important because the absorption of carbohydrates occurs primarily in the duodenum and jejunum, the first two-thirds of the small intestine, in which the food stays only for a short time, a little over half an hour. Blending and cooking at pH 2.0 increases both the rate and extent of hydrolysis. In this case some of it is due to the fact that about 30 percent is hydrolized before incubation with the enzyme.

We felt that those in vitro results justified some in vivo experiments to determine the extent and rate of hydrolysis of the different components in the diets. Two groups of rats which were previously used for feeding experiments, which I shall describe later, were used. One group was fed a diet containing cooked whole beans, the other group was fed a diet containing beans blended raw and cooked at pH 3.5.

Staining the intestinal contents with iodine indicates that the bean starch is much more digestible than raw corn starch, which was present to supplement the diet. The starch granules in the bean cells readily stain before ingestion; however, those removed from the stomach are predominantly unstained. Figure 5 shows the intestinal contents of the first one-third of the small intestine stained with iodine. Very rarely were there iodine-stainable bean cells beyond this section. All iodine-stainable material, including corn starch, disappeared before the last one-third of the small intestine.

The bean cellular oil stained well with Sudan B. Bean cells stained heaviest around the cell exterior. No Sudan B-stainable material was found in the second one-third of the small intestine.

The ninhydrin stainable protein in the bean cells appeared to be located between the starch granules. From figure 6 it would seem that there is little ninhydrine stainable material in this section of the intestinal content. This slide represents intestinal contents from the last one-third of the small intestine which will indicate that most of the bean protein was digested and absorbed in the small intestine.

Figure 5.--Photomicrograph of rats' intestinal contents stained with iodine for detection of starch.

There are no recognizable cell structures in the samples of blended cooked beans. When staining with different stains, the background stained always darker before digestion. We can assume that the suspended starch, protein, and oil was absorbed very early in the small intestine.

Characteristically, the outer structural shell of the bean cell remains intact throughout digestion. The cell appeared to be leached of distinguishable nutrients yet retain much of its original form and structural appearance. The remaining material inside the cell looked like a thin cellulose-like starch granule shell.

Preliminary feeding experiments suggested that the protein efficiency ratio (PER) might be lower for beans in

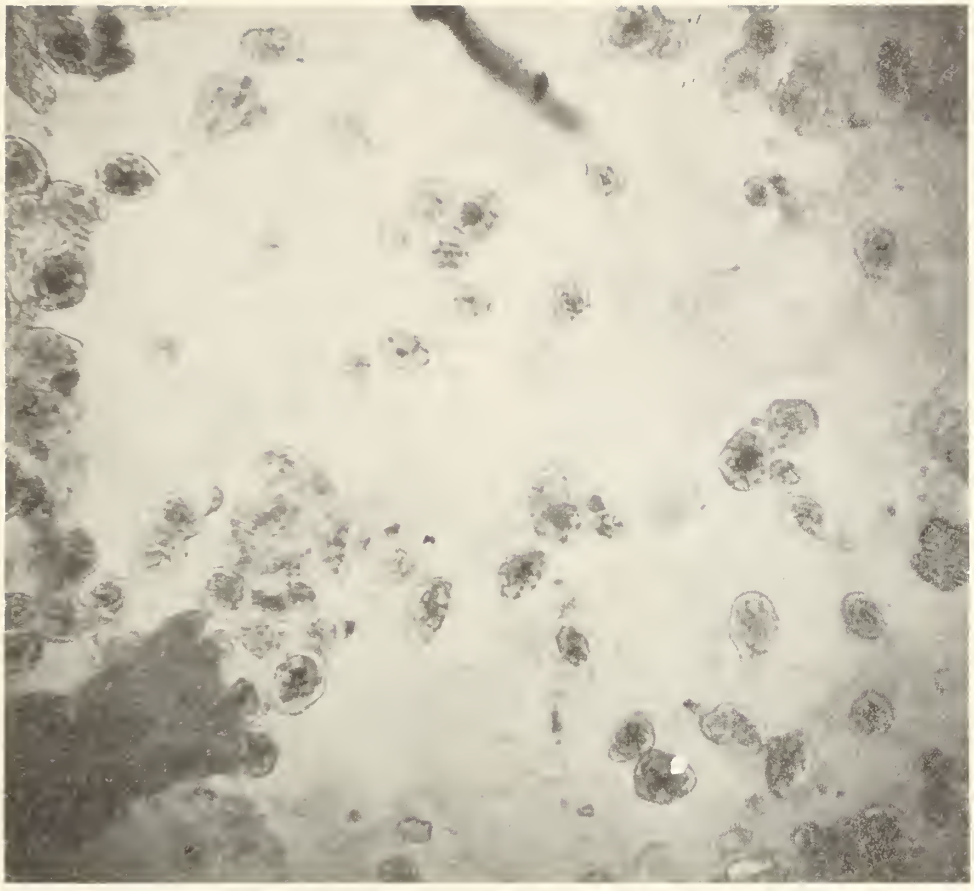

Figure 6.--Photomicrograph of rats' intestinal contents stained with ninhydrin for detection of proteins.

the acid-treated slurry as compared with that for the whole cooked beans. For this reason we decided to try different treatments to remedy this situation. Rats were fed diets with gross composition as indicated in table 7. The experimental products used were: 1) whole beans soaked overnight and cooked for 1 hour, blended for one-half minute; 2) raw beans blended for 5 minutes with acidified water to make a slurry at pH 3.5, cooked for 1 hour, and neutralized; 3) same as in (2) but more acid was added, making a slurry at pH 2.0 which was then centrifuged to make a milk and then cooked, and neutralized. When cooking at pH 6.7 was used (table 8), the slurry or milk was cooked for 15 minutes at the original pH (3.5 or 2.0) and then the pH was adjusted to 6.7 and cooked for the remaining 45 minutes. It was necessary to cook the acidified slurry or milk in the acid pH to inactivate lipoxidase and prevent the development of

TABLE 7.--Composition of rat diets

Nutrients	Diet	Dietary source
	Percent	
Protein	10	Experimental products only.
Oil	8	Experimental products and corn oil.
Salts	5	Experimental products and salt mix XIV and Zn and Co.
Fiber	3	Experimental products and cellulose.
Carbohydrates	47	Experimental products and dextrose.
Corn starch	20	Corn starch.
Vitamins	2	Vitamix
H_2O	5	--

off-flavors. As can be seen from table 8, it is evident that cooking the bean slurry at pH 3.5 lowered the PER as compared with that of the whole beans. Other results in this table suggest that some methionine was lost during the cooking of the slurried material at the acidic pH. Losses of up to 60 percent of methionine have been reported on complete acid hydrolysis in the presence of carbohydrates. The conditions of our treatment are, of course, not as drastic as those of acid hydrolysis, but may be drastic enough to cause some loss of methionine and cysteine. This loss must be responsible for the poor PER exhibited by those samples, especially if we remember that methionine is the limiting amino acid in beans. Tryptophan, which is the second limiting amino acid in beans and is very sensitive to acid, does not seem to be affected by the acid treatment. Supplementing the diet with tryptophan did not improve its PER. Whatever the reason, all of the bean samples, whole and slurried, had significantly lower PER values compared to casein. This can be remedied by supplementing the bean samples with 200 mg. methionine per gN. This will bring the total S containing amino acids in the beans to about 320 mg. per gN, which is somewhat higher than the FAO provisional pattern of 270 mg. per gN which will allow for some losses during cooking. The slurry cooked at pH 6.7 and supplemented with methionine had a significantly higher PER value when compared to casein. The slurried material supplemented with methionine gives a product which is more digestible and has a better PER than the whole beans supplemented with methionine.

To summarize--this talk reports the development of two main products from legume seeds. One is a slurry of the whole seed in question, the other is a legume milk which is high in protein and contains up to 80 percent of the legume protein. The two products are very bland and free of any oxidative off-flavors and odors and can be used in different food formulations to increase the nutritional quality of the food items. They can also be fabricated into new food items which will be very nutritious and can be flavored to suit the consumers.

TABLE 8.--Effect of different treatments of bean products on weight gain, protein efficiency ratio, and digestibility by rats

Dietary source of protein[1]	Mean body weight gain ± Standard Deviation[2]	PER[3] Actual ± Standard Deviation	PER[3] Corrected	Digestibility[4]
				Percent
Casein	96.0 ± 17.3	2.99 ± 0.24	2.50	94.75
Bean Products:				
Whole beans	40.9 ± 11.3[5]	1.79 ± 0.25[5]	1.50	92.42
Slurry cooked at pH 3.5	26.4 ± 14.3[5]	1.29 ± 0.20[5]	1.08	93.15
Slurry cooked at pH 6.7	35.0 ± 12.6[5]	1.64 ± 0.11[5]	1.37	93.12
Whole beans + methionine[6]	110.8 ± 18.2	3.19 ± 0.21	2.67	91.47
Slurry cooked at pH 3.5 + meth.[6]	86.8 ± 18.5	2.85 ± 0.09	2.38	93.50
Slurry cooked at pH 6.7 + meth.[6]	103.1 ± 10.2	3.28 ± 0.18[7]	2.74	93.34
Milk cooked at pH 6.7	36.0 ± 10.6[5]	1.51 ± 0.24[5]	1.26	93.93
Milk cooked at pH 6.7 + meth.[6]	100.6 ± 22.5	3.08 ± 0.14	2.57	92.86

[1] All diets contained 10 percent protein. [2] Eight male weanling rats per group. S-D Strain (SPF) 25 days old with mean initial weight 56.0 g-28 days' assay. [3] PER = gain in weight/gram protein eaten. [4] Digestibility = $\frac{\text{feed intake - fecal weight}}{\text{feed intake}}$ X 100. Data from 5 rats per group. [5] Significantly lower than casein at $P < 0.01$. [6] Supplemented with 200 mg. methionine/gN. [7] Significantly lower than casein at $P < 0.05$.

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ARTIFICIAL DRYING OF RED KIDNEY SEED BEANS[1/]

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Red kidney beans to be used for seed are being grown in a number of counties in the northern part of Michigan. In years with wet falls it is necessary to dry the beans artificially to assure high viability of the seed. No reliable information is available on the drying rates of kidney bean seeds nor on the maximum allowable temperature which can be employed in drying the seeds.

It is, at the present time, common practice among kidney seed growers to dry the beans in homemade, stationary bed dryers. A dryer has a wooden drying chamber with a perforated floor; the height of the drying bed is between 1 and 2 feet. Wet beans are dumped into the dryer and are expected to dry to at least 18 percent wet basis in 1 or 2 days. Drying air temperatures used by the seed growers vary between 50° and 100° F.; no reliable information is available on the airflow rates.

The main objective of this study on the artificial drying of red kidney bean seeds was to learn enough about the drying behavior of this crop so that recommendations can be made to the kidney bean growers regarding the temperatures, airflow rates, initial moisture contents, and maximum bed depths to be used during the drying operation. Because it is impossible to test each drying situation to be encountered in practice in the laboratory, a computer model of the kidney bean dryer had to be developed and tested with rewetted kidney beans from the 1969 growing season. After it had been established that the mathematical model simulated the stationary bed drying of kidney beans reasonably well, the effect of the various parameters affecting the drying process had to be established on a digital computer.

[1/] This study was partly supported by the Michigan Bean Commission. The authors thank two undergraduate agricultural engineering students Steve deBoer and Lloyd E. Lerew for their contributions made to this study.

Red kidney beans at an initial moisture content of 12 percent wet basis were obtained directly from a bean grower in Michigan. Two lots were used for the drying and germination tests. The first lot was of inferior quality and had a very low germination percentage (less than 30); the second lot had a much higher viability (over 92 percent germinibility). The seeds were wetted to approximately 30, 25, 22 and 18 percent moisture content, wet basis, and stored in moisture-proof bags at 35° F. until they were used in the investigation. The storage at the rewetted condition lasted up to 7 weeks.

First, simple layers of kidney beans were dried in trays at temperatures between 50° and 120° F. at a relative humidity of 60 percent. The trays were weighed hourly so that the drying rates of the beans could later be calculated. After 24 hours' drying the beans were removed from the dryer and the germination rate of 100 beans was determined, using standard seed-testing techniques.

The second part of the drying tests was performed by placing the kidney beans in a 6-inch-diameter, 15-inch-long Plexiglass container which had a perforated bottom. Air was circulated with a variable-speed fan through the container and through a conditioning unit capable of controlling temperature and relative humidity. The airflow was measured with a laminar flow element and a micromanometer. Flow through the element was linearly related to the pressure differential across the measuring section with 1 in W.G. differential corresponding to 5 $ft.^3$/min. air. The micromanometer, which indicated the pressure differential, had a range of 0 to 10 in W.G., reading to 0·001 in W.G. The speed of the series wound motor driving the fan was regulated with an autotransformer in the motor circuit.

Temperatures of the air before, after, and at selected points within the bed were measured with thermocouples connected to continuous recording potentiometers. Thermocouples in the bed were encased in small perforated cylinders to prevent their contacting the product.

Relative humidity was measured with an electric hygrometer. Sensing elements were positioned in the airstream before and after the bed.

Moisture contents of the kidney beans were found by placing the beans in a 210° F. air oven for 24 hours.

Bakker-Arkema and coauthors have developed a number of simulation models for the drying and cooling of beds of agricultural products (1, 2, 3). The present model for drying kidney beans is a modification of the corn-drying model (1969). Those interested in the specifics of the kidney bean simulation drying model are referred to a technical bulletin to be published on the subject (4).

Germination Tests.--The results of the germination tests on kidney beans dried at different temperatures and initial moisture contents are tabulated in table 1. Drying with air temperatures of 120° F. resulted in decreased germination regardless of the initial moisture contents of the kidney bean samples. At air temperatures of 100° F. or less, drying did not deteriorate the seed. However, loss of germination did occur when seed at high initial moisture content was stored for long periods at 38° F. before drying.

At moisture contents of approximately 25 percent and above, it is believed that the loss of viability was due to seed decomposition before the drying tests. Seed at those moisture contents could not be satisfactorily stored for more than approximately 2 weeks without loss of germination even at a controlled temperature of 38° F.

The data in table 1 lead to the conclusion that seed harvested from the field at high moisture contents requires drying as quickly as possible at approximately 100° F. or less. The amount of time this seed can be held before drying without significant losses in viability will depend somewhat on the storage temperatures but should under no circumstances be longer than 2 weeks.

Thin Layer Tests.--Twenty-one drying tests performed between 44° and 120° F. showed that the drying of individual kidney bean seeds can be described satisfactorily by the equation

$$\frac{1}{D}\ \frac{\partial M}{\partial t} = \frac{\partial^2 M}{\partial x^2} \qquad (1)$$

if in the numerical solution five modes are employed in solving the equation with Dx = 0.00175 ft. In equation 1:

t = time, hour
x = bean thickness, feet
D = diffusion coefficient, square feet per hour
M = moisture content, wet basis, decimal

TABLE 1.--Germination of red kidney bean seed wetted to different moisture contents and dried for 24 hours

Drying temperature °F.	Initial moisture content, wet basis	Days after rewetting	Normal growing	Abnormal growing	Dead
	Percent	Number	Percent	Percent	Percent
Control	12.0	--	87	5	8
120	29.58	20	16	6	78
120	26.67	20	66	1	33
120	20.63	20	61	8	31
120	13.79	20	58	6	36
110	28.51	13	62	11	27
110	23.26	13	85	3	12
110	20.35	13	83	9	8
110	17.36	13	87	3	10
100	27.53	6	75	18	7
100	22.21	6	76	19	5
100	18.39	6	84	11	5
100	17.61	6	82	13	5
93	28.25	15	63	10	27
93	26.67	15	82	4	14
93	20.63	15	91	2	7
93	13.79	15	86	9	5
70	27.63	34	56	11	33
70	25.32	34	83	5	12
70	23.88	34	76	9	15
70	20.73	34	87	4	9
53	28.86	49	31	5	64
53	27.93	49	77	9	14
53	24.63	49	61	13	26
53	21.64	49	84	8	8

The diffusion coefficient is a function of the drying air temperature as well as of the bean moisture content:

$$D = 0.0012 \exp. \left\{(0.00025\ T + 0.010720)\ 100\ \overline{M} - \frac{4430.0}{T + 524.0}\right\} \quad (2)$$

In equation 2, T and $\overline{M}$ represent the drying air temperature (F) and the average kidney bean moisture content, respectively.

Table 2 shows the experimental and theoretical results of drying kidney beans at temperatures between 50° and 100° F. at a relative humidity of 60 percent. The relative humidity determines the final or equilibrium moisture content of the product but otherwise does not affect the drying rate of kidney beans materially. Temperature plays an important role as is evident when the drying rates of kidney beans at 50° and 100° are compared.

Table 2 shows that the experimental and theoretical drying rates agree reasonably well. There was a maximum difference between the measured and predicted moisture contents of 1.7 percent with an average difference of less than 1.0 percent.

Deep Bed Drying.--The experimental and theoretical drying data of a 15-inch-deep bed of kidney beans agreed well. The air temperatures and bean moisture contents were checked for a number of tests. The empirical and simulated results were always within 2.0° F. and 1.7 percent moisture content of their predicted values.

Tables 3 through 6 show the results of the parametric deep bed drying study of rewetted kidney beans. The effects of air flow, of drying temperature, of inlet humidity ratio, and of initial moisture content are illustrated in the tables.

The importance of air flow on the drying rate is obvious if the 10 and 30 cfm./bu. airflow rates are compared (table 3). After 24 hours the beans dried at 10 cfm./bu. have barely started to dry at the 1-foot level, while at a depth of 2 feet the moisture content is still higher than at the start of drying, because of condensation. The bed dried at 30 cfm./bu. is, on the other hand, completely dry after 24 hours.

Similar remarks can be made regarding the effect on the drying rates of air temperature (table 4), of the

TABLE 2.--Simulated and experimental (in parentheses) moisture contents of rewetted kidney bean seeds dried at four temperatures; relative humidity 60 percent

Drying time	Moisture contents at drying air temperature of --							
	50° F.		60° F.		80° F.		100° F.	
Hours	Percent		Percent		Percent		Percent	
0	28.6	--	28.6	--	28.6	--	28.6	--
4	22.6	(24.0)	21.8	(23.2)	20.5	(22.2)	19.1	(18.9)
8	20.3	(21.9)	19.4	(20.0)	17.8	(19.1)	16.2	(14.6)
12	18.7	(19.8)	17.8	(18.3)	16.1	(17.5)	14.6	(13.1)
16	17.5	(18.7)	16.6	(17.1)	15.0	(16.2)	13.7	(12.8)
20	16.5	(18.3)	15.7	(16.5)	14.2	(15.0)	13.0	(12.4)
24	15.8	(17.9)	15.0	(15.2)	13.5	(14.8)	12.4	(12.0)

TABLE 3.--Moisture content distribution at two positions within a bed of rewetted red kidney beans dried at three airflow rates; drying air temperature 100° F., humidity ratio 0.005 lb./lb.

Drying time	Moisture content after drying at airflow rates of --					
	10 cfm./bu.		20 cfm./bu.		30 cfm./bu.	
	1 ft.	2 ft.	1 ft.	2 ft.	1 ft.	2 ft.
Hours	Percent					
0	28.6	28.6	28.6	28.6	28.6	28.6
4	29.7	29.7	29.7	29.7	29.7	29.7
8	29.7	29.7	29.3	29.7	20.2	29.7
12	29.7	29.7	19.9	29.7	16.1	29.4
16	29.7	29.7	16.2	29.7	13.5	20.1
20	29.7	29.7	13.7	29.7	11.8	16.4
24	21.2	29.7	12.0	21.3	11.9	13.2

TABLE 4.--Moisture content distribution at two positions within a bed of rewetted red kidney beans dried at three air temperatures; airflow rate 30 cfm./bu., humidity ratio 0.005 lb./lb.

	Moisture content after drying at temperatures of --					
	60° F.		80° F.		100° F.	
Drying time	1 ft.	2 ft.	1 ft.	2 ft.	1 ft.	2 ft.
Hours	Percent					
0	28.6	28.6	28.6	28.6	28.6	28.6
4	29.0	29.4	29.5	29.5	29.7	29.6
8	29.0	29.8	29.5	29.5	20.2	29.7
12	27.6	29.9	26.6	29.5	16.1	29.4
16	23.1	29.9	20.9	29.5	13.5	20.1
20	20.3	29.9	17.9	29.5	11.8	16.4
24	18.5	29.9	15.8	29.5	10.9	13.2

TABLE 5.--Moisture content distribution at two positions within a bed of rewetted kidney beans dried at two humidity ratios; air temperature 80° F., airflow rate 30 cfm./bu.

	Moisture content after drying at humidity ratios of --			
	0.005 lb./lb.		0.010 lb./lb.	
Drying time	1 ft.	2 ft.	1 ft.	2 ft.
Hours	Percent			
0	28.6	28.6	28.6	28.6
4	29.5	29.5	29.7	29.7
8	29.5	29.5	29.5	29.8
12	26.6	29.5	26.5	29.9
16	20.9	29.5	21.2	29.9
20	17.9	29.5	18.3	29.9
24	15.8	29.5	16.4	29.9

TABLE 6.--Moisture content distribution at two positions within a bed of rewetted kidney beans dried at two initial moisture contents; air temperature 100° F., airflow rate 20 cfm./bu., humidity ratio 0.005 lb./lb.

Drying time	Moisture content after drying; initial content of --			
	22.0 Percent		28.6 Percent	
	1 ft.	2 ft.	1 ft.	2 ft.
Hours	Percent			
0	22.0	22.0	28.6	28.6
2	22.5	22.4	29.7	29.7
4	22.5	22.4	29.7	29.7
6	17.5	22.4	29.7	29.7
8	16.0	22.4	29.3	29.7
10	14.7	22.4	22.8	29.7
12	13.7	18.1	19.9	29.7

humidity ratio of the drying air (table 5), and of the initial bean moisture content (table 6). Each table illustrates the importance of changing one of the drying parameters.

It is not possible to include all the kidney bean drying data simulated in this study within this paper. The results do, however, show trends and allow prediction of drying rates if the drying conditions fall within the ranges of tables 3 through 6. For different conditions it will be necessary to use the simulation model in conjunction with a digital computer. For an on-line facility the answers can be obtained within 1 hour.

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OBSERVATIONS ON BEAN PROCESSING--AND A NEW BEAN PRODUCT

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I was given the job of carrying out process developmental studies on the products that Sam Kon has just discussed. Observations on the processability of the 1969 crop of California small whites refute a number of well-known "facts," both published and unpublished. I intend to tell you what I have observed. This leaves me in the same position that David was in when he went out to tangle with Goliath and probably will make me unpopular, because nobody likes to hear about new problems.

We are all acquainted with the fact that some lots of small whites are difficult to rehydrate. "Fact" No. 1 is that small whites that hydrate well do not lose that ability on storage, if stored at proper temperatures and moisture contents. One lot of small whites was purchased from a commercial source in October 1969 for process studies. Hydration for 45 minutes in water at 150° F. was established experimentally as a step in the process. By April 1970 the same lot of small whites had lost their ability to hydrate to such an extent that I was forced to change my process from a wet grinding step to a dry grinding step.

In April, two new lots of small whites were purchased from the same commercial source as the first lot. Both lots contained many "hardshells" that did not hydrate at all during 18 hours of soaking in water at room temperature. The nonhardshells did not hydrate properly in the 45-minute hot water step established with the first lot of beans. "Fact" No. 2--the water supply has been changed and calcium ion is interfering with the hydration. Not so--the beans responded identically to tapwater and distilled water.

"Fact" No. 3--steam or water blanching will make hardshells hydrate. I quote a conclusion from a paper by Morris, Olson, and Bean (2): "A practical method used for processing hardshell beans was a short heat treatment in either hot water or steam." Small whites were not included in these studies, but the conclusions applied to four varieties, ten strains of beans. Not so--blanching of small whites from the second and third lots had no effect on

the hydration (or lack thereof) of the hardshells. As far back as 1927, Bigelow and Fitzgerald (1) reported: "Some samples of small white California beans that soaked incompletely in tepid water were found to soak even less satisfactorily after preliminary blanching." Problems with beans are obviously not new!

"Fact" No. 4, quoting again from the Morris paper: "The kind of hardshell beans encountered in this study does not require any special treatment for canning purposes, since the minimum retorting necessary for adequate sterilization is a sufficient cook to make them palatable." Not necessarily so. About the same time that we ran into hydration problems, a commercial processor told us that he had a whole warehouse full of canned small whites that contained many hardshells that did not fully hydrate or cook during retorting, even though the beans were retorted for 10 minutes longer than needed to assure sterility.

"Fact" No. 5--Small whites from the southern part of the Salinas Valley are different from those from the northern part. The processor went back to the supplier of the troublesome beans. He was told that the difference in the soil types between the northern and southern part of the Salinas Valley was very likely responsible for the hydration problem. Not necessarily so. Lot 1 of my beans was obtained from an elevator in Santa Maria; Lots 2 and 3 from an elevator in Salinas. Yet all three lots had deteriorated seriously in their ability to hydrate.

It would appear that the 1969 crop of California small whites is quite different from what we have seen before and may be unique. I have no solutions to offer, so I'll change the subject and tell you about a new bean product that is a spin-off from our process studies.

Considerable effort has been devoted to the development of quick-cooking dry beans. Two approaches have been used. Precooked dry beans are available in supermarkets at the present time. The other approach has been to infuse the beans with salts that reduce cooking time (3,4). In fact, the next talk on this program will be on the infusion method.

During our process studies on the bean products that Sam Kon discussed, we decided to peel the beans to reduce the fiber content of the finished products. We tried a number of routes, but the best results were obtained with a Ce-Co-Co Mill, which is basically a tapered Carborundum rotor turning inside a slotted screen. This mill is a sort

of mixed-up item. It is manufactured in Japan, and the name tag calls it a "Barley and Wheat Polishing (debranning) Machine." However, it is widely used in California to mill rice which we ship to Japan.

Peeling the beans has led to a strictly mechanical (and cheap) way of making quick-cooking beans. Small whites are readily peeled in the Ce-Co-Co mill with a recovery of 90 percent of the weight fed to the mill. When the peeled small whites are dropped into boiling water, the bean halves spread apart within 2 or 3 minutes so that the thickness that has to be penetrated by the water is only half that of the unpeeled bean. When fully cooked, the beans are completely separated into halves. Is anyone interested in promoting a new product, peeled bean halves that are quick-cooking and chemically pure?

The cooking time on several lots of peeled small whites was about 30 minutes when the samples were prepared. Cooking time for unpeeled small whites in boiling water, starting with unsoaked beans, was 85 minutes. Similar results were obtained with red beans and pinto beans, but the cooked products were less attractive than the small whites because the Ce-Co-Co mill does a poorer job of peeling flat beans than it does on the rounder small whites.

Incidentally, peeling the beans cured the hardshell problem that we encountered in Lots 2 and 3 of small whites. The peeled beans cooked uniformly, showing conclusively that impervious skins are the cause of this particular type of hardshell in small whites.

The changing character of the beans led me to repeat the cooking tests 5 months after the peeled small whites were prepared. Sure enough, the cooking time had increased from 30 minutes to 40 minutes, showing that changes were occurring in the bean meats themselves.

I have only one conclusion to draw--more research on dry beans is badly needed.

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RECENT PROGRESS ON THE DEVELOPMENT OF NEW AND IMPROVED QUICK-COOKING PRODUCTS FROM LIMA AND OTHER DRY BEANS

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Preparation of New and Improved Frozen Products from Dry Beans

The basic process involves: (1) loosening seedcoats of the dry beans by one of several alternative procedures adapted specifically for each variety; (2) hydration of the cotyledon in a solution of common food-grade inorganic salts; (3) soaking in the hydration medium; (4) rinsing; and (5) freezing. Conditions suitable for the production of several types of frozen beans from dry beans are presented in table 1. The Hydravac process (6) is employed for loosening seedcoats of large dry limas. However, a pretreatment with steam or hot water is used to loosen the seedcoats on some of the smaller common beans before soaking in the salt solution. Blanching time depends upon the initial bean quality and the blanching method employed. Steam blanching may require more than twice as long as hot water blanching. The frozen large limas prepared as outlined in table 1 may be cooked within 8 to 10 minutes.

Most of the other common beans require from 10 to 15 minutes to tenderize in boiling water. Further studies on processing conditions will be required to optimize the process for many of the other common dry beans, depending upon their quality and individual characteristics. The tendency for quick-cooking beans to foam excessively during cooking may be minimized by the addition of a small amount of a food-grade antifoaming agent.

The processed beans have an enhanced natural flavor, uniform texture, and excellent color. Their general appearance is enhanced if they are individually quick frozen (IQF) and loosely packed. Moisture translocation and the formation of ice crystals within a transparent package tend to detract from the overall appearance. An opaque package with an appropriate illustration may be most suitable for the retail market.

TABLE 1.--Summary of processing conditions employed for laboratory preparation of quick-cooking frozen beans from dry beans

Processing operation	Dry bean variety					
	Lima, large Ventura	Lima, baby green or speckled	Lima, baby emerald green	Pinto or kidney	Calif. small white	Blackeye
Blanch time in boiling water--minutes	0	3	2	2	3	1
Drain, add hydration medium composed of the following food-grade or USP salts:						
Sodium chloride--percent in aqueous solution	1.0			2.0		
Sodium tripolyphosphate--percent in aqueous solution	.5			1.0		
Sodium bicarbonate--percent in aqueous solution	.75			.75		
Sodium carbonate--percent in aqueous solution	.25			.25		
Hydravac cycle: 5 minutes on/off total time--minutes	60	0	0	0	0	0
Soak time at 70° F., followed by light rinse, draining, and freezing--hours	5	24	24	24	24	18
Subjective cooking time--minutes	8 to 10			10 to 15		

Nutritional Quality of Frozen, Quick-cooking Large Lima Beans

The protein in either untreated or processed raw beans is unavailable for growth of experimental animals. Hydrated beans must be cooked to obtain maximum nutritional benefits from bean protein. Because large, quick-cooking frozen limas require only a short cooking time, it was important to establish the nutritional availability of lima bean protein after the minimum cooking time required to tenderize the product. Studies on the protein efficiency ratio (PER) by the Pharmacology Laboratory, WURDD, under the supervision of A. C. Keyl and A. N. Booth, have shown that the full nutritional quality of large, frozen limas is developed during a cooking period of 5 minutes (table 2). A slight reduction in the PER values was observed for products cooked up to 30 minutes.

Activity of Various Bean Products for Stimulation of Gas Production by C. Perfringens

In order to further evaluate the utility of an improved microbiological assay procedure, the relative activities of rice, barley, and lima beans were redetermined. The relative activities of the cook waters were also evaluated (table 3). In general the relative activities of rice and barley, which are not considered flatulent, were low and corresponded with the results obtained in previous studies (6). The activity of drained, quick-cooking limas, estimated by microbiological assay, was only about 70 percent as high as that of the limas prepared in the conventional manner. In addition, significant activity was observed in the cook water of all products. Cook waters from rice and barley had low activities equal to about one-half of the activity of the combined product and cook water. Cook waters from both untreated and processed limas had significant activity levels equivalent to about 40 percent of the total. Activities of other processed beans alone or the processed beans plus cook water were considerably lower than those of similar, untreated beans (table 4). The relative activities of processed lima, pinto, and blackeye beans were only 40 to 50 percent of the corresponding untreated beans contained in their cook water (table 5).

These data and subjective judgments by taste panel members suggested that the quick-cooking process may have also reduced the flatulence characteristic of the processed lima beans. This hypothesis was tested by a coordinated

TABLE 2.--Effect of cooking time on the nutritional qualities of frozen, quick-cooking large dry lima beans[1/]

Sample		Cooking time	Mean body weight (27 days)	PER[2/]	Digestibility	Pancreas
Material	Treatment	Minutes	Grams		Percent	Percent of body weight
Casein	None	--	139.2	2.50	93	0.53
Lima beans	None (control)	50	95.5	1.92	90	.51
Lima beans	Quick cooking	5	109.7	1.96	90	.54
Lima beans	Quick cooking	15	95.7	1.84	90	.56
Lima beans	Quick cooking	30	87.3	1.71	89	.51

[1/] Feeding studies conducted by A. N. Booth, Pharmacology Laboratory, WURDD, July 1969. [2/] Protein efficiency ratio determined on weanling rats for 27 days.

TABLE 3.--Activities of various cooked products for stimulation of gas production by *C. perfringens*[1/]

Product	Activity		
	Product	Cook water	Combined, product and cook water
Long-grain rice	0.3	0.2	0.5
Pearl barley	.4	.3	.7
Large dry lima beans	1.5	.9	2.4
Quick-cooking large lima beans	1.0	.7	1.6

[1/] Relative to activity of a standard preparation of a hydrated, raw, large dry lima bean slurry.

TABLE 4.--Microbiological activities of standard and quick-cooking frozen large lima, pinto, and blackeye beans prepared from dry beans[1/]

Bean variety	Beans, cooked and drained		Beans, cooked, with cooking water	
	Standard	Quick-cooking	Standard	Quick-cooking
Blackeye	1.0	0.7	1.8	1.5
Lima	1.4	1.0	2.7	2.1
Pinto	4.5	3.1	6.0	4.0

[1/] Microbiological assay with C. perfringens. Values relative to a standard slurry of raw, large dry lima beans taken as 1.0.

TABLE 5.--Relative microbiological activities of drained, cooked quick-cooking beans compared with cooked, undrained standard beans[1/]

Bean variety	Drained, quick-cooking/undrained standard
Blackeye	0.39
Lima	.37
Pinto	.52

[1/] Microbiological assay with Clostridium perfringens.

study of the relative microbiological activities and human flatulence characteristics of identical samples of drained quick-cooking lima beans and their untreated controls assayed with their own cook water. The flatulence assays (1) were conducted by E. Murphy of the Western Utilization Research and Development Division, Albany, Calif., in cooperation with D. Calloway at the University of California, Berkeley (2). The microbiological assays were conducted at the Pasadena Laboratory (4). Breath hydrogen production and flatus gases were determined to evaluate the response of human subjects to the quick-cooking and untreated lima beans (table 6). Lower hydrogen and flatus volumes were observed for the processed products compared with those for the untreated beans. The relative values observed for the drained quick-cooking samples ranged from about 40 to 60 percent of the unprocessed beans assayed with their own cook water (table 7), compared with a corresponding value of 43 percent obtained by the microbiological assay procedure. In terms of actual flatus gases observed in 13 individual human assays conducted on drained quick-cooking limas compared with the gases in standard undrained limas,

TABLE 6.--Comparison of flatulence activities of cooked, frozen quick-cooking and standard large dry lima beans[1/]

Criterion	Standard beans			Quick-cooking beans
	Lot 1	Lot 2	Average	Lot 2
Hydrogen, average values--p.p.m., 3 to 7 hours	31	28	30	17
Hydrogen, peak value--p.p.m.	54	43	49	25
Flatus, total volume--cc. in 3 hours	425	198	312	115

[1/] Human assays (2) corrected for bland formula levels. Each value represents the average of 4 replicate assays.

TABLE 7.--Comparison of human flatus assays and microbiological assays of standard and frozen, quick-cooking large dry lima beans

Assay method and criterion	Relative activity (Quick-cooking/standard)[1/]	
	A	B
Human:[2/]		
Hydrogen, average values--p.p.m., 3 to 7 hours	0.61	0.57
Hydrogen, peak value--p.p.m.	.58	.50
Flatus, total volume--cc. in 3 hours	.58	.36
Average	.59	.48
Microbiological:		
Average of 8 assays, single lot	.43	--
Average of 19 assays, mixed lots	--	.43

[1/] A, four replicate human assays, single bean lot; B, same as A for quick-cooking beans compared with eight replicates from two standard lots of beans.
[2/] Murphy and Calloway (2).

the relative flatus activities averaged 42 percent. This value compared favorably with 19 replicate microbiological assays on similar materials (table 8).

Quick-cooking Refrigerated Bean Products from Dry Beans

Imbibition of water by dry beans normally initiates the germination process among viable seeds. Immersion in water for periods of more than 24 hours usually devitalizes the beans and fermentation causes a sour flavor and odor to develop. In solutions of the common salts employed for the preparation of quick-cooking bean products, fermentation was greatly inhibited even when beans were not pretreated by blanching or Hydravac treatment to devitalize the seed (fig. 1). Addition to the hydration medium of a small

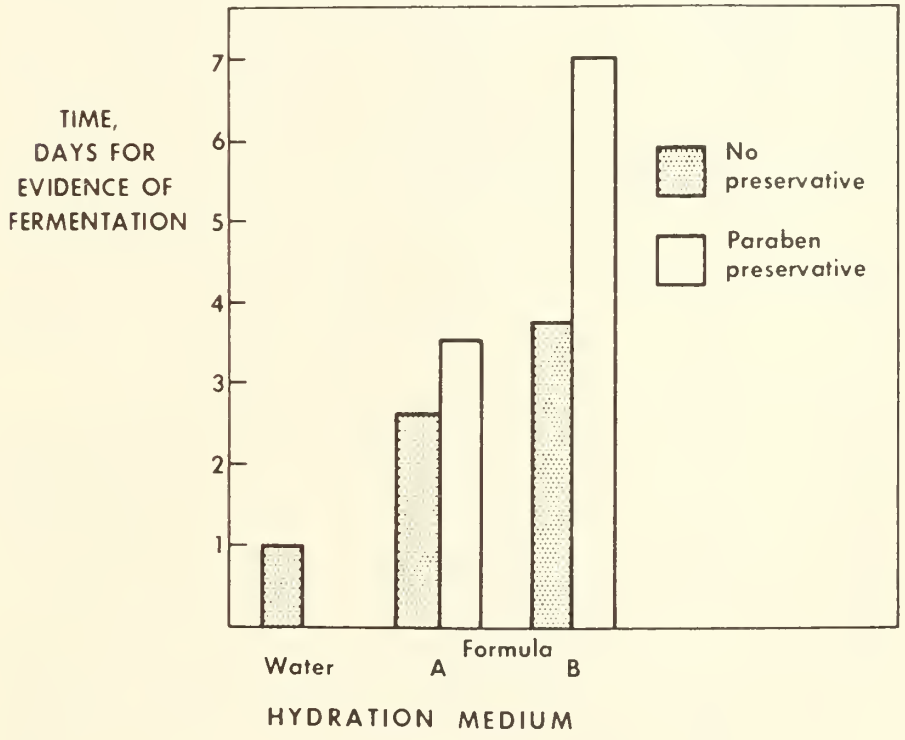

Figure 1.--Effects of salt solutions and preservative on fermentation of large dry lima beans during total immersion in hydration and soaking at 70° F.: Formula A. Standard formula containing 1.0 percent sodium chloride; Formula B. Standard medium containing 2.5 percent sodium chloride.

TABLE 8.--Summary of human flatus assays compared with microbiological assays of processed, quick-cooking large dry lima beans

Assay date	Type	Lot no.	Replicates	Flatus volume in 3 hours		Relative activity[1/] (Processed/control)
				Control	Processed	
				Cc.	Cc.	
January 1965	Dry	478	1	327	147	0.45
	Dry	479	2	327	161	.49
July 1966	Dry	764	3	147	48	.33
	Frozen	761	3	147	69	.47
March 1970	Frozen	278-56	4	311	115	.37

[1/] Average, 13 human assays (2), 0.42; average, 19 microbiological assays (Pasadena Laboratory), 0.43.

amount of a food-grade bacteriostatic agent, such as methyl and propyl p-hydroxybenzoate almost doubled the time required for fermentation to develop at ambient temperature.

On the basis of these preliminary observations, a series of systematic studies was initiated to determine if conditions could be found which would permit large dry lima beans to be converted to a fully hydrated product that would remain stable for an extended period at normal refrigerator temperatures. It may be seen in table 9 that processing conditions were developed for the preparation of hydrated quick-cooking large dry lima beans which retained satisfactory flavor, color, general appearance, and quick-cooking characteristics for up to 10 weeks at 40° F. Although the process has not yet been optimized, progress has been made on the development of preliminary conditions for preparing quick-cooking lima, pinto, and blackeye beans which remained acceptable for up to about 9 weeks at 40° F. (table 10). Although no serious microbiological problems are anticipated for products processed under sanitary conditions and held under refrigerated storage for limited periods of time, bacteriological studies will be required to determine the influence of storage on the quality, acceptability, and utility of the refrigerated products. A short gentle heat treatment or pasteurization of the processed products may be expected to further increase their stability and storage quality.

Refrigerated beans have many of the same advantages as the frozen or redried, quick-cooking beans. Lower production and handling costs may compensate in part for their limited shelf life. For institutional use, such as in dormitories, school lunch programs, restaurants, or local markets which can be served regularly, the limited shelf life may not be a serious disadvantage. If required, the products may also be held in frozen storage. However, the nonfrozen products are more convenient to utilize. Quick-cooking refrigerated beans may also find acceptance as consumer products in the semiperishable section of retail food markets.

Quick-cooking frozen or refrigerated beans can be employed in most common recipes for rapid and convenient preparation of soups, salads, bean pastes, snacks, and standard cookbook recipes. Their low cost, convenience, enhanced flavor, uniform texture, and fine appearance should stimulate increased utilization of these nutritious, high-protein foods.

TABLE 9.--Procedures for preparing refrigerated, hydrated quick-cooking large dry lima beans

Hydration method	Hydration medium[1/]	Total salt	Soak time	Maximum shelf life (40° F.)	Subjective cooking time		Flavor quality cooked
					Initial	Final	
		Percent	Hours	Weeks	Minutes		
Normal	Water	0	18	< 1	55	55	Bland.
Hydravac	Standard	4.5	2	10	11	9	Good.
			4	9	9	9	Good.
			6	8	8	9	Good.
	Standard plus NaCl	5.0	6	8	8	10	Satisfactory.
		5.5	6	8	9	10	Slightly salty.
		6.0	6	8	9	11	Salty.

[1/] Standard formula: 2.5 percent sodium chloride, 1.0 percent sodium tripolyphosphate, 0.75 percent sodium bicarbonate, 0.25 percent sodium carbonate, 0.05 percent each of methyl and propyl para-hydroxybenzoate.

TABLE 10.--Procedures for preparing refrigerated, hydrated quick-cooking dry beans

Bean variety	Presoak treatment	Hydration medium		Soak time	Maximum shelf life (40° F.)	Subjective cooking time
		NaCl level[1/]	Total salt			
		Percent	Percent	Hours	Weeks	Minutes
Large lima	Hydravac	2.5	4.5	4	9	9
Pinto	Blanch	3.0	5.0	24	9	14
Blackeye	None	3.0	5.0	24	9	11

[1/] NaCl as given, 1.0 percent sodium tripolyphosphate, 0.75 percent sodium bicarbonate, 0.25 percent sodium carbonate, and 0.05 percent each methyl and propyl para-hydroxybenzoate.

Summary

The development of a process for preparing quick-cooking, frozen lima beans from large dry limas was reported previously (3,5). Preliminary studies were also reported on the preparation of frozen bean products from dry pinto, small white, kidney, blackeye beans, and soybeans. Improvements have been made in processing techniques and small-scale commercial production and marketing tests have been initiated for several varieties. Processing conditions have been elaborated for the preparation of other dry beans including baby limas and emerald green baby limas. The latter have the unique property of resembling fresh green beans, but have the flavor characteristics of a dry bean. Additional information has also been obtained concerning the nutritional quality of frozen quick-cooking large lima beans. Further comparisons have been made between human flatus assays and a microbiological assay procedure (4). The latter measures the stimulation by various bean products of similar gases produced by a common strain of the intestinal microorganism, Clostridium perfringens. Work is also in progress on the development of low-cost, nonfrozen, refrigerated whole bean products from dry beans. These products may find application in institutional feeding programs, hotels and restaurants, or in the semiperishable section of retail food markets.

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A CHANGING PICTURE OF U. S. AGRICULTURAL EXPORTS

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As it is very appropriate to this gathering this morning, I would like to share with you a special report on U.S. agricultural exports in the sixties which was just prepared by our Commerce Department's Bureau of International Commerce in Washington.

American farm exports increased during the 1960's but much less rapidly than shipments of other products. As a result, their share of our total exports declined to 16 percent from 25 percent at the beginning of the decade.

The trend in exports of agricultural commodities during the 10-year period was uneven. From $4.8 billion in 1960, exports rose to an all-time high of $6.9 billion in 1966 but declined in the next 3 years. By 1969, they had dropped to $5.9 billion. Because of the poor export performance in recent years, the average annual rate of increase in farm shipments was held to only 2.3 percent in the sixties, about one-fourth the growth rate in other U.S. exports.

In general, foreign demand for imports--as determined principally by year-to-year fluctuations in output abroad--has been the major factor influencing U.S. farm exports. Programs to promote greater self-sufficiency--notable in the European Economic Community (EEC), the United Kingdom, and Japan--and the adoption of protectionist policies have contributed importantly to the expansion of farm output overseas.

The increase in U.S. farm exports has been due entirely to greater commercial sales. These shipments advanced to $4.9 billion in 1969, more than two-fifths greater than at the start of the decade.

The commodity pattern of U.S. agricultural exports has been characterized by strong gains in shipments of soybeans, feedgrains, and other animal feeds. Rising world demand for these products reflected the improvement in foreign living standards as evidenced by greater consumption of meat. On the other hand, exports of wheat and

cotton declined in the sixties. This development was primarily the result of increased world output.

Although western Europe remained the largest market for U.S. farm exports throughout the sixties, its relative importance has declined since the beginning of the decade. Japan, on the other hand, increased its share of the export total as a consequence of strong demand there for our soybeans and corn. Among the developing areas of the world, East and South Asia received the largest share of U.S. agricultural exports in the 1960's.

Farm commodities associated with rising living standards and increased meat consumption abroad have paced the long-term expansion in U.S. agricultural exports. The largest dollar rise occurred in sales of soybeans which soared from $336 million in the beginning of this decade to $822 million. Unlike most commodities, shipments moved consistently upward as a result of strong markets in western Europe and Japan. In the EEC, demand for U.S. soybeans was stimulated by the substitution of this commodity for the higher priced feedgrains. While soybeans are primarily used to provide protein meal for poultry and cattle, an important byproduct is an oil derivative used in margarine, shortening, and cooking oils. Rising at a rate of 11 percent a year, shipments of corn increased from $285 million to $726 million. The advance stemmed entirely from commercial sales.

Meat exports also reached new heights, increasing by almost three-fourths to $199 million last year. Shipments to Canada, Japan, and the EEC accounted for most of the gain.

From $379 million in 1960, exports of unmanufactured tobacco rose to a record $540 million. Shipments have been especially buoyant in the last 4 years as a result of United Nations trade sanctions imposed on Rhodesian tobacco in 1966. Sales to western Europe--mainly the EEC countries and the United Kingdom--account for the bulk of these exports.

Japan's vigorous economic growth, improving living standards, and the consequent upgrading of traditional diets made that country our fastest growing market for farm commodities in the sixties. From $485 million in 1960, sales nearly doubled to $934 million last year. Most of the advance stemmed from greater deliveries of corn and soybeans for the growing poultry and pork industries there. The production of these meats has more than tripled in

Japan during the sixties. Sales of wheat also rose to higher levels but cotton shipments fell off sharply.

Sales to western Europe, which account for nearly three-fifths of our exports to the developed regions, increased by only $53 million since 1960. The major factor holding down the expansion in these exports was the more than $400 million drop in cotton shipments during the sixties.

The impact on U.S. agricultural exports of the EEC's Common Agricultural Policy (CAP) appears to have been substantial, particularly after the establishment of unified markets in mid-1967 for grain (except rice), pork, eggs, and poultry. The system of variable levies set up under the CAP nullifies any price advantage nonmember countries may enjoy and guarantees a high level of support prices to Community farmers. Stimulated by high prices, protection from foreign competition, and favorable weather, farm supplies of member countries expanded enormously in the last 3 years. As a result, U.S. exports declined from their 1966 peak of $1,559 million to $1,269 million in 1969. A further adverse effect on our shipments was the increase in competition in third-country markets, both from the heavily subsidized EEC exports and from other suppliers to members who shifted some of their sales efforts elsewhere.

Deliveries to Canada totaled $710 million last year compared with $432 million in 1960. A large portion of the increase was due to greater deliveries of fruits and vegetables. Commercial exports of dry edible beans in the marketing year ending August 1969 were $25.6 million. This was a 32-percent increase over the level of $22 million in 1968.

From 1960 through 1969, the U.S. share of world exports fell from 20.8 percent to 18.4 percent. In manufactured goods alone, the U.S. share dropped to a postwar low in 1969 of 22.3 percent, a decline of 1.1 percent points from the previous year. Our total exports reached $37.3 billion in 1969. The President's Cabinet Committee on Export Expansion, headed by Secretary of Commerce Maurice H. Stans, has set a U.S. export target of $50 billion a year by 1973, an increase of almost $13 billion over 1969.

In the Commerce Department, we are improving and expanding our export promotion programs in an effort to achieve this goal; we are identifying products with the best export potential and planning ahead for the next 5 years in close cooperation with U.S. companies. Although the major portion of our Commerce Department promotional

services are geared for the sales of manufactured goods abroad, we do offer basic services which are of assistance to agricultural suppliers.

For example, a firm wishing to research the most promising export markets for his product will certainly wish to examine our Census Bureau's Foreign Trade Report, FT-410 series. This statistical compilation provides value and quantities of more than 3,000 U.S. products shipped to some 169 countries. By reviewing U.S. exports of your products for the past 3 or 4 years, you will be able to identify which countries have been the biggest, most consistent buyers. An evaluation of foreign competition can be undertaken through the medium of our Market Share Reports. These reports contain statistics on imports of more than 1,100 commodities by countries over several years. Here you can trace the changing levels of import demand for your products in these countries and the relative competitive positions of the major supplying countries. Our monthly Foreign Production and Commercial Reports Index identifies reports prepared by our commercial officers abroad on commodities (many of them agricultural), industries abroad, and economic trends, country by country and also by Standard Industrial Classification Code.

Many of the firms in this area that are active in selling their products abroad ascribe their success to the caliber of their overseas representation. The Commerce Department now offers a new service known as the Agent/Distributor Service (ADS) which will help you to locate an appropriate representative in foreign markets at a nominal fee of $10 per country. We have devised a brief form which permits you to name the qualifications you are seeking in a potential agent. This is forwarded to our commercial staff at the U.S. Embassy in the country of interest. They are required within 1 month to complete the back of the form, identifying several local firms that seem to meet the requirements you have indicated.

In order to assist you in evaluating each of these prospects, we can also provide World Trade Directory Reports for $2 each. These reports furnish background information on specific foreign firms prepared by the U.S. Commercial Officers and include information on type of organization, method of operation, lines handled, size of firm, sales territory, capital, sales volume, reputation in trade circles, etc. We have reported on over 118,000 firms abroad.

In concluding, substantial assistance is available not only from Federal agencies but also from private organizations, such as banks, and Chambers of Commerce. However, in the final analysis it is you, Mr. Businessman, who must take the initial action to put yourself in the export business.

BREAKING INTO THE EXPORT MARKET

George Nakata
Pacific Supply Cooperative
Portland, Oreg.

I would like to address my remarks today toward examining one segment of our Pacific Northwest industry--namely, the pea and lentil industry--and recent positive moves to gain a larger share in the world marketplace. At the outset, some background information might be in order.

During World War II, peas were a price-supported commodity used extensively by the Army in dry soup formulas because of their high nutritional value. After the completion of the governmental programs, producers and processors alike were deeply concerned as to the future of the dry pea business. Historically, the domestic use of dry edible peas has been one million bags--yet during World War II, production reached ten million bags. The obvious answer with the cutback in governmental purchases seemed to be a curtailment of production. Up to that time, exports had been generally limited to the Caribbean and a few South American countries.

Our organization, Pacific Supply Cooperative, a regional agricultural cooperative headquartered in Portland and made up of some 100 Northwest member associations rendering supply and marketing services, was, of course, concerned in a very real sense because many of our members were heavily involved in peas, beans, and lentils. This meant participation by members as well as the parent organization in major discussion.

Then, several years ago some meaningful moves took place. It became apparent that the industry needed some united effort by a producer-processor-exporter organization and, hopefully with the help of USDA Foreign Agricultural Service (FAS), prompt and positive action had to be taken in expanding export markets.

As a result of this joint effort, a special foreign marketing development committee was formed in early 1964 by the Idaho Association of Dry Pea and Lentil Producers and Pacific Northwest Pea Growers and Dealers Association. This committee was the beginning of the U.S.A. Dry Pea and Lentil Council.

The committee was composed of three growers, two processors, and one exporter. I happen to be the exporter representative to this sixman board at the present time The sole purpose of the U.S.A. Dry Pea and Lentil Council was to administer the foreign market development activities for the industry.

Initially the aim was to develop markets in cash-buying countries, and efforts on the part of the industry were further directed toward the development of additional new markets. Personal visits to many of these markets have been made by industry members at their own expense. Also, many industry teams have been dispatched to put on exhibits, participate in fairs, and spread the word of the quality, uniformity, and reliability of U.S.A. dry peas and lentils. It should be noted that the export markets in general have been developed by the industry strictly as dollar markets, with no subsidy or governmental aid.

During the past few years, some 200 million pounds of dry peas and lentils per year have been shipped to nearly 40 countries scattered throughout the world.

In late 1964, a program agreement (contract) with the FAS was signed authorizing some monies in counterpart funds in preparation for our initial activity.

Since that time we have engaged the services of a full-time Marketing Director headquartered in Spokane, Wash.; participated in the Tokyo and Osaka International Trade Fairs; initiated the project "Golden American Peas" with Nichiro-Heinz for sales throughout Japan; participated in the Ikofa Exhibition in Munich, Germany, as well as the Sial Exhibition in Paris, France; sponsored the visit of three Japanese canning executives to the producing areas of the Pacific Northwest; produced 1,800 sample cards depicting our peas and lentils for mailing throughout the world; worked jointly with a French research firm to identify the cooking characteristics of U.S. lentils for the European processors; and, recently, dispatched an industry team to promote a program in Latin American for our commodities. Last month I participated in a three-man mission to Europe, examining the export programs for U.S. dry peas and lentils in the United Kingdom, France, Germany, and Italy.

As all of you know, one cannot treat Europe as an area, but must examine in depth each specific country to study its unique and unusual marketing requirements, to

fulfill its specific pea and lentil needs, and to successfully answer its challenges.

All of us must constantly guard against trade barriers, a major concern. For example, the Common Market created some import duties against our peas and lentils, as compared with the free flow of goods across their own borders. There exists a 7.2-percent duty against our peas and beans and a 3.8-percent duty against our lentils. Our hope, of course, is to work through organizations such as General Agreement on Tariffs and Trade (GATT) and the Kennedy Rounds; and thus far we have succeeded in reducing these duties in 1972 to 4.5 percent on peas and beans and 2 percent on lentils.

Service, as well as price and quality, is vital in agricultural marketing. In Italy, at one of the largest canners in the country, we ran into the problem in canning. This particular firm, just starting to can our lentils, found that we had, in fact, good-quality lentils, but for some unusual reason during the cooking process they continued to split or to burst. Now we are in France going through extensive research in order to resolve this problem through tests and cooking investigations. The U.S. lentil is a quick-cooking commodity so, hopefully, we will have a prompt answer for the Italian processors.

In Germany, it was a different challenge. U.S. lentils at one time provided the major portion of Germany's requirements; but, in 2 short years, we find that Russian lentils have taken away a full 60 percent of the German import requirements. Here is a case where it is extremely difficult for any individual company to compete against a state or country. Here is the U.S.S.R. that has bought their way into the market, and the challenge remains as to how we can regain our fair share of the German lentil requirement. We examined the Russian contracts and certificates and verified that price was no obstacle to them.

The U.S. pea and lentil has one strong international advantage. In short, our U.S. lentils are known for their "good cooking quality." It is a solid, reliable quality and, in general, is free from weevils, has low moisture, is of quick cooking quality, and is acceptable to many countries abroad. This strong advantage, however, has not received the publicity and promotion that it rightfully should have. There is a challenge to make the consumer aware of the fact that we do produce top-quality pulses in the United States.

Thus, our industry has put on many exhibits and in-store promotions and mailed out sample cards, and many individual exporters have taken trips abroad to spread the word of our quality products from the Pacific Northwest.

Our own company has exhibited, for example, in U.S. Trade Centers abroad and has dispatched many samples; and we have taken developmental trips to Asia and Southeast Asia, as well as to Europe. All of us must continue this hard-hitting program and keep expanding our network of agents and representatives as well as contacting of major canners and processors abroad.

I am certain that agencies and organizations such as Pacific Supply Cooperative, for their future in agriculture, must move in dedicated fashion to innovate and capture an important share of the oversea markets.

There is much work to be done.

Market intelligence must be refined, good communications must be retained with agricultural attachés abroad, close cooperation with FAS, the USDA, and the U.S. Department of Commerce must be realized, and full coordination by all facets of government and industry with common interests in agriculture must take place, so that exports through broad-based, united, and meaningful efforts will result in true expansion.

CALIFORNIA DRY BEAN RESEARCH AND MARKETING PROGRAM

John S. Cox
California Lima Bean Advisory Board
Westley, Calif.

During the past 2 years a number of individuals and groups involved in the production of marketing of dry beans grown in California have been exploring various methods of increasing and stabilizing the returns from their industry. Numerous meetings have been held, involving such groups as: Farm Bureau Bean Commodity committees; an organization of blackeye growers known as the San Joaquin Bean Growers; the California Bean Growers Association, a marketing cooperative; the Stockton District Kidney Bean Growers, Inc., a marketing cooperative; the California Bean Dealers Association; the California Warehouseman's Association; and the California Lima Bean Advisory Board, the administrative agency for the State marketing order on large limas. Also participating were research and extension personnel from the University of California and economists from the Bureau of Marketing, California Department of Agriculture.

As a result of these many meetings, two programs were launched: (1) the formation by bean handlers of the California Dry Bean Research Council in May 1968 to raise funds for needed research through voluntary contributions by growers, dealers, and warehousemen; and (2) the establishment of a Research Expansion Committee by the Lima Bean Advisory Board in August 1968 to investigate the feasibility of and support for the formation of a Dry Bean Program under the California Marketing Act of 1937.

It became obvious from the support given both programs that there was general agreement on the need for an organized effort to develop, finance, and administer research and promotion necessary to improve returns and perhaps even to prevent the collapse of the dry bean business in California. It also became apparent that maintaining two programs would mean unnecessary cost and duplication.

Representatives of these two groups met on several occasions to discuss programs and to study the advantages and disadvantages of both the voluntary and marketing order approaches. Accordingly, in May 1969 the Board of Directors of the California Dry Bean Research Council voted to cosponsor, along with the Lima Bean Advisory Board, an effort to develop and promote a Dry Bean Program under the

California Marketing Act. Joint committees were augmented by additional persons, representing all varieties of beans grown in California, to develop plans for explanatory meetings throughout the state and to recommend to the California Director of Agriculture that he take whatever legal steps were required to submit for industry approval the proposed program to the vote of all producers and handlers covered under the program.

This was accomplished, and on July 8, 1970, sufficient assents were collected from both producers and handlers, voting separately, to assure passage of this Program. Accordingly, the Director of Agriculture certified that the Program was approved, and he issued the Order to be effective July 15, 1970.

The California Dry Bean Research and Marketing Program, (as are all California Marketing Orders), is a legal entity with powers to prepare, finance, and administer such activities as have been written into its program by the California dry bean industry. However, this marketing order is unique in that it provides for producer representation by varietal categories and sets up separate varietal councils, or subboards, to conduct special activities which will affect only the variety involved. General activities affecting the industry as a whole are to be developed and administered by an Advisory Board composed of 16 producers, who are the chairman and vice-chairman of each of eight varietal councils and nine handlers, comprising five dealers and four warehousemen selected at-large by each of these handler groups.

The Program covers the producers and handlers of all dry beans grown in California and marketed commercially. Assessments will be recommended annually by the Advisory Board in order to finance the activities currently selected by the Board, and to be applicable to all handlers and producers of the current crop production. Maximum assessment rates per hundred weight for each group have been established as a measure of fiscal control.

The main objective of this Program is to do whatever is possible to increase the income from and the marketability of all California dry beans. The Program authorizes the following research activities:

(1) Utilization research to determine the superiority of California-grown beans and to improve consumer acceptance of these beans and bean products.

(2) Production research of a general nature which attacks grower problems common to all varieties.

(3) Market research which evaluates consumer and retailer needs covering all varieties.

(4) Engineering research to improve the techniques of handling and storing beans from field to consumer.

A second set of general objectives is the promotion of California beans as a desirable food commodity. This could involve the following activities:

(1) Recipe and product development.

(2) Contacts with trade and consumer-influencing groups.

(3) Publicity and public relations.

(4) Advertising and product demonstration.

A third category of activities anticipated are those which fall under the powers of the Board, but which are subject to the prior approval of the producers directly involved through their representatives on one or more of the varietal councils. Special activities that may come under these safeguards are:

(1) Minimum grade regulations.

(2) Varietal improvement research.

(3) Promotion applicable to a single variety or less than one-half of all varieties under the Program.

This Program became effective on July 15, 1970, and will remain in effect unless terminated at the end of any season by exercise of certain provisions of the California Marketing Act. Also, as required by recent amendment of the Act, this Program must be submitted to referendum of all producers and handlers for reapproval or termination every 5 years after its initial effective date.

Incidentally, I made reference previously to two organizations which had been interested in bean research. It has now been decided by the Lima Bean Advisory Board and the California Dry Bean Research Council Board of Directors that these two organizations will suspend their activities until the success of the new Dry Bean Program has been assured. Each Board will then decide the future fate of its own organization.

It is a great honor to have been chosen by the California dry bean industry to serve as the initial Dry Bean Advisory Board chairman. I will do whatever I can to assist this Program in becoming operative and to succeed in meeting its objectives.

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